ADVANCES IN GRASSLAND HUSBANDRY AND FODDER PRODUCTION

SECOND SYMPOSIUM

DEPARTMENT OF AGRICULTURAL BOTANY
READING UNIVERSITY
ENGLAND.

BULLETIN 38

of the

IMPERIAL BUREAU OF PASTURES AND FIELD CROPS
ABERYSTWYTH, GREAT BRITAIN

May, 1947

Price: 6s. 0d.

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CONTENTS

		Page
	Foreword	4
15.*	Research Programme on Veld and Pasture Management in Southern Rhodesia, by O. West and J. M. Rattray	5
16.	The Economics of Ley Farming, by A. W. Ashby	23
17.	The Present Centres of Intensive Formation of Plant Species, by I. S. Travin	29
18.	Forage Production in Switzerland, by A. Kauter	37
19.	A Scottish Method of Grassland Improvement	45
20.	Agricultural Seed Production as a New Industry in Welsh Farming	47
21.	Grassland Research and Advisory Work in Sweden	51
22.	Birdsfoot Trefoil as a Forage Legume	54
23.	Hay Dehydration in the South-western United States	56
24.	U.S. Regional Pasture Research Laboratory	57
25.	Pasture Investigations in Victoria	60
26.	Grass Productivity Studies in a Tropical Lowland	64
27.	Weeds in Fiji	75
28.	Pastures and Fodder Plants in Sierra Leone	78
29.	Land Resources of Tripolitania	82

*Items 1 to 14 appeared in the first symposium, published as Bull. 32 (see inside back cover)

DEPARTMENT OF AGRICULTURAL BOTANY
READING UNIVERSITY
ENGLAND.

FOREWORD

This second symposium continues the practice adopted in the first of the series in bringing together a miscellaneous collection of articles, quotations and reviews from the world literature. A reviewer of the first symposium remarked that it was difficult to find a central theme connecting the fourteen items published therein. The central theme is the provision of fodder for animals from cultivated crops or natural vegetation, and the very miscellaneous nature of the items in these two symposia is an indication of the great variety of conditions under which that fodder is required and the wide range of problems directly or indirectly involved in its production.

This second symposium contains four articles, two published here for the first time, one translated from Russian, and one reproduced from an English farming paper for the further information of workers in other countries who may not have seen the original. The subjects covered in these four articles are the research programme in Southern Rhodesia (article submitted through R. R. Staples, Govt. Ecologist), the problem of the economics of ley farming (in which Prof. Ashby cotinues the discussion begun in I.A.B. Joint Publ. No. 6), a statement of the effect of the war and its aftermath on forage production in Switzerland, illustrated by photographs of contrasted land-use patterns, and an exploratory article on an unusual subject by our Russian Corresponding Editor.

The section of reviews and quotations covers a wide range of subjects, from Dr. J. W. Gregor's method of improving upland grazings, the use of birdsfoot trefoil as a forage legume in the north-eastern United States, and the work at the U.S. Regional Pasture Research Laboratory in Pennsylvania, to items of tropical interest such as grass productivity in the lowland pastures of Queensland, the control of noxious weeds in Fiji, and the potential herbage and forage plants of Sierra Leone. A high ideal which might well be adopted in all tropical lands liable to serious erosion, but which is difficult to carry out because of pressure on the land, is expressed in the last-mentioned item, namely, that if live stock cannot be kept without favouring erosion, their numbers should be reduced to a minimum in Sierra Leone ; a fodder plant is not primarily desirable because of its palatability or nutritive value, but because it is capable of preventing erosion—fodder value is a secondary requirement. If this ideal is to be accepted more widely—as it must ultimately be—it will become obvious that great advances in the technique of producing fodder will be necessary if farmers and graziers are to hope to meet the present and future world demand for animal products.

RESEARCH PROGRAMME ON VELD AND PASTURE MANAGEMENT IN SOUTHERN RHODESIA

MATABELELAND, BY O. WEST.
MASHONALAND, BY J. M. RATTRAY.

INTRODUCTION

The accepted scheme of veld and pasture research for the Colony includes the development of two Central Research Stations, one on the Rhodes Matopo Estate to serve Matabeleland, and the other at Marandellas to serve Mashonaland ; each has four or five sub-stations to cover all the major veld types or ecological regions.

Southern Rhodesia lies between latitudes 15° and 22°S. and longitudes 25° and 33°E. and covers an area of approximately 150,350 square miles. It has a European population of about 81,000 of which, according to the 1941 census, close on 4000 farmers were engaged in agriculture, and a native population of nearly one and a half million.

The country is divided politically into two provinces, Matabeleland and Mashonaland, and each province is again divided into districts, making a total of thirty-one in all. In each district a certain portion of land has been set aside exclusively for the use of natives and these are known as native reserves and native purchase areas. About 30 per cent of the total area of the country is thus occupied.

TOPOGRAPHY AND CLIMATE

Topographically, Southern Rhodesia consists of a great central plateau of high elevation running in a belt roughly from the south-west to the north-east and sloping gently on either side to the low-lying valleys of the Zambesi River in the north and the Limpopo and Sabi Rivers in the south. The central plateau is a broad stretch of country above 4000 feet in elevation terminating in a range of mountains of 6000 to 8000 feet in the east, and is commonly referred to as the high veld. The low-lying valleys of the northern and southern boundaries lie between 1000 and 2000 feet and are known as low veld, while the sloping country on either side of the plateau is regarded as middle veld. The average rainfall over the whole country is about 28 inches but this varies considerably with elevation, under 15 inches falling in some of the southern low veld and well over 40 inches in some parts of the high veld. The rainy season usually starts about October and finishes about April, with the highest averages in January and February. The highest mean temperatures are recorded in December and January, while frosts occur in the high and middle veld from May to September.

MATABELELAND

BOUNDARIES. The Matabeleland Province of Southern Rhodesia extends from the Zambesi in the north to the Limpopo River in the south. To the west and south-west it is bordered by the Bechuanaland Protectorate, and is divided from Mashonaland to the east by a boundary which runs roughly from the confluence of the Sanyati and the Zambesi Rivers to the confluence of the Bubye and the Limpopo Rivers. It includes the districts known as the Midlands centred on Gwelo.

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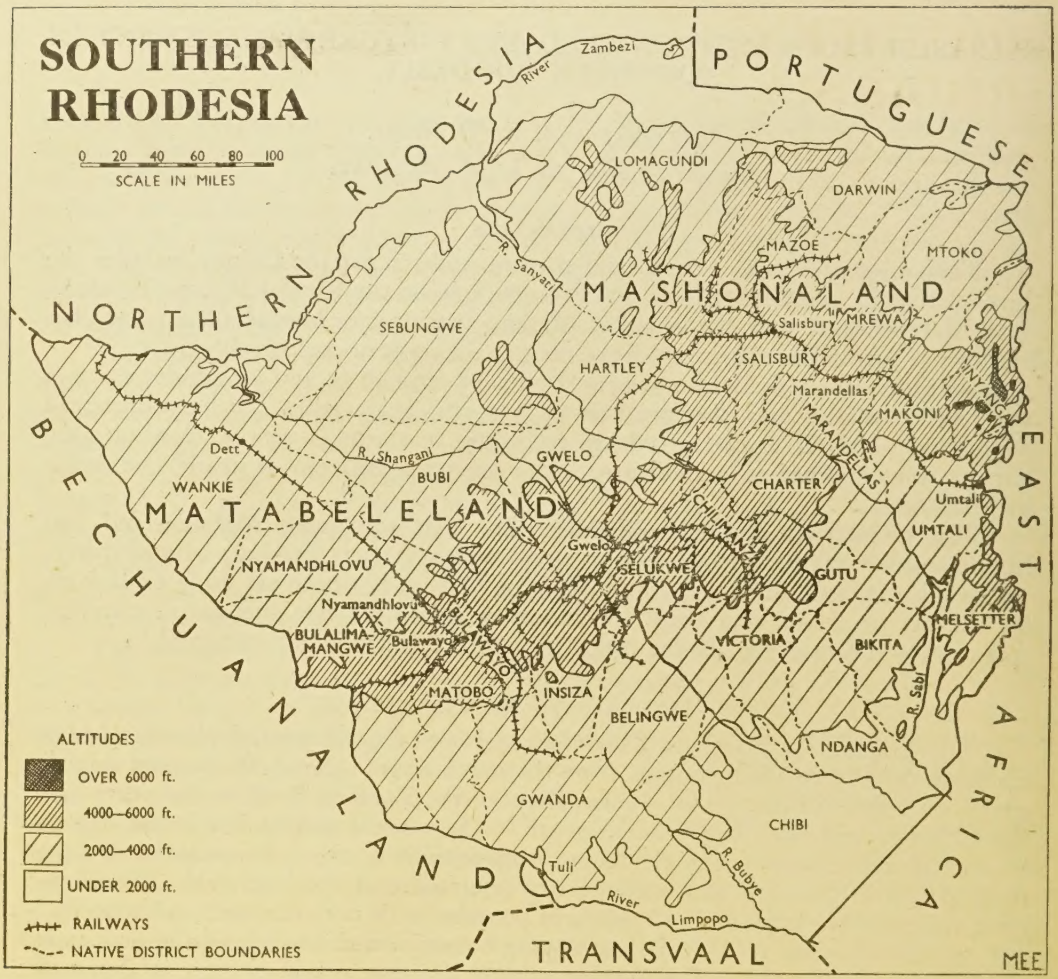
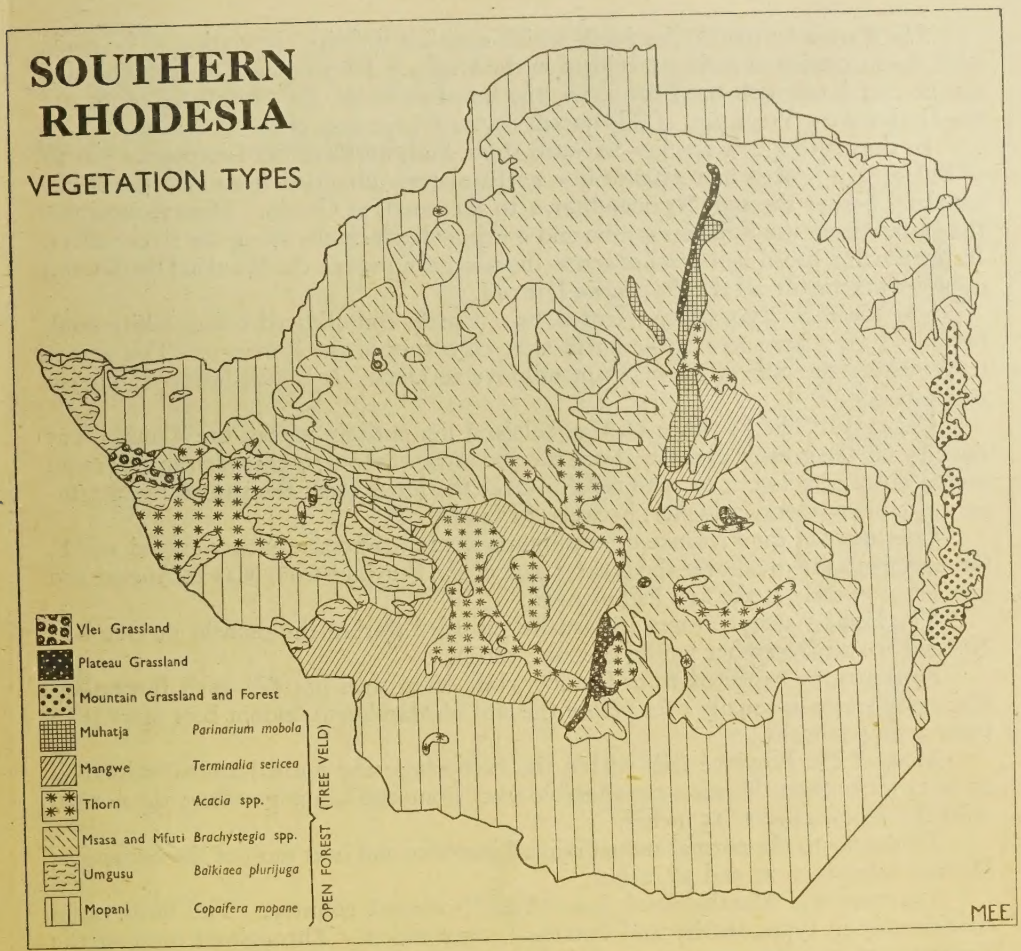


The total area of Matabeleland proper is 44,875,520 acres. The Province is, therefore, considerably larger than England.

Topography. The lowest country is found in the north and in the south along the valleys of the Zambesi and Limpopo Rivers and along their principal tributary valleys. Here there are considerable tracts which lie below the 2000 foot contour, but on the whole the Province is at higher elevations, by far the greater part being above the 3000 foot contour.

A plateau of high ground stretches across the country in a west-south-west to east-north-east direction. This plateau is of subdued relief and was formed by the gentle uplift of a plain. The axis of the uplift forms the main watershed from which the rivers flow north-west to the Zambesi and south-east to the Limpopo.

Geology. *The Basement Schists*, a complex geological system correlated with the Swaziland system of Archaean age, are the oldest rocks in the Province. They



are exposed over a large part of the area covered by the high central plateau. Great sheets of intruded granite often surround the exposures of the basement schists and cover most of the south-eastern half of the Province.

The Lomagundi System, which rests unconformably on the basement schists and on some of the granite extends across the western boundary of the Sebungwe district in the north-eastern corner of the Province. This system is considered to be of the same age as the Transvaal-Nama system and consists of a very thick succession of conglomerates, quartzites, dolomites, slates, etc.

The Great Dyke of Norite traverses the Province in a north-easterly direction from the Doro hills in Belingwe, passing to the east of Selukwe and through Lalapanzi into Mashonaland. It is probable that the Great Dyke is of the same age as the Bushveld Complex of the Union of South Africa and is younger than the Lomagundi system.

The Karroo System carries fossils which enable a definite correlation to be made with the succession of rocks established in the Union. Four series of beds exist which can be correlated with the Ecca series, the Beaufort series, the Stormberg series and the Drakensberg Volcanics. This system covers a large area of the Province.

In the south a belt reaches eastward from Tuli, north of the Limpopo. North of Bulawayo a broken belt extends in a north-easterly direction from near the Bechuanaland border through Nyamandhlovu to the north of Gwelo. Here it separates the granite from the Kalahari system and is exposed principally along the river valleys. In the north a broad belt reaches across the northern part of the Wankie District and occupies practically all the Sebungwe District.

The Kalahari System, represented by a loosely consolidated red or white sand, occupies a very large area in the north-western corner of the Province. This area is traversed by the railway from Nyamandhlovu to Dett. It carries heavy Rhodesian teak forest.

Climate. The Province of Matabeleland lies entirely within the Tropics, but since by far the greater part lies above the 3000 foot contour, it enjoys an annual mean temperature of between 72° and 65°F. Over the lower areas the annual mean temperature is considerably higher, between 82° and 70°F.

Over most of the Province the maximum shade temperatures may exceed 100°F. Ground frosts are usual over the greater part of the Province from May to August and may occur as early as the first half of April.

The highest temperatures are usually recorded during the months of October, November and December before the rains set in.

Rain may be expected from October, but often does not fall until December. The rainy season is usually over before the end of March and seldom lasts more than from 3 to 4 months.

Most of the Province falls within the belt where the normal annual rainfall is 20 to 25 inches, but there is a considerable tract along the Limpopo where the normal rainfall is as low as 10 to 15 inches.

To the north the normal annual rainfall increases and over most of the Sebungwe District is between 25 and 30 inches.

Vegetation. Matabeleland is a "bush"-covered country. The bush varies considerably in type, density and botanical composition. Throughout most of the Province a more or less open savannah is the characteristic vegetation and this is maintained principally by periodic burning. There is a marked tendency almost everywhere for the bush to increase in density where firing is not practised either, deliberately or as the result of over-grazing.

The principal types of vegetation have been described by Henkel (1931)*.

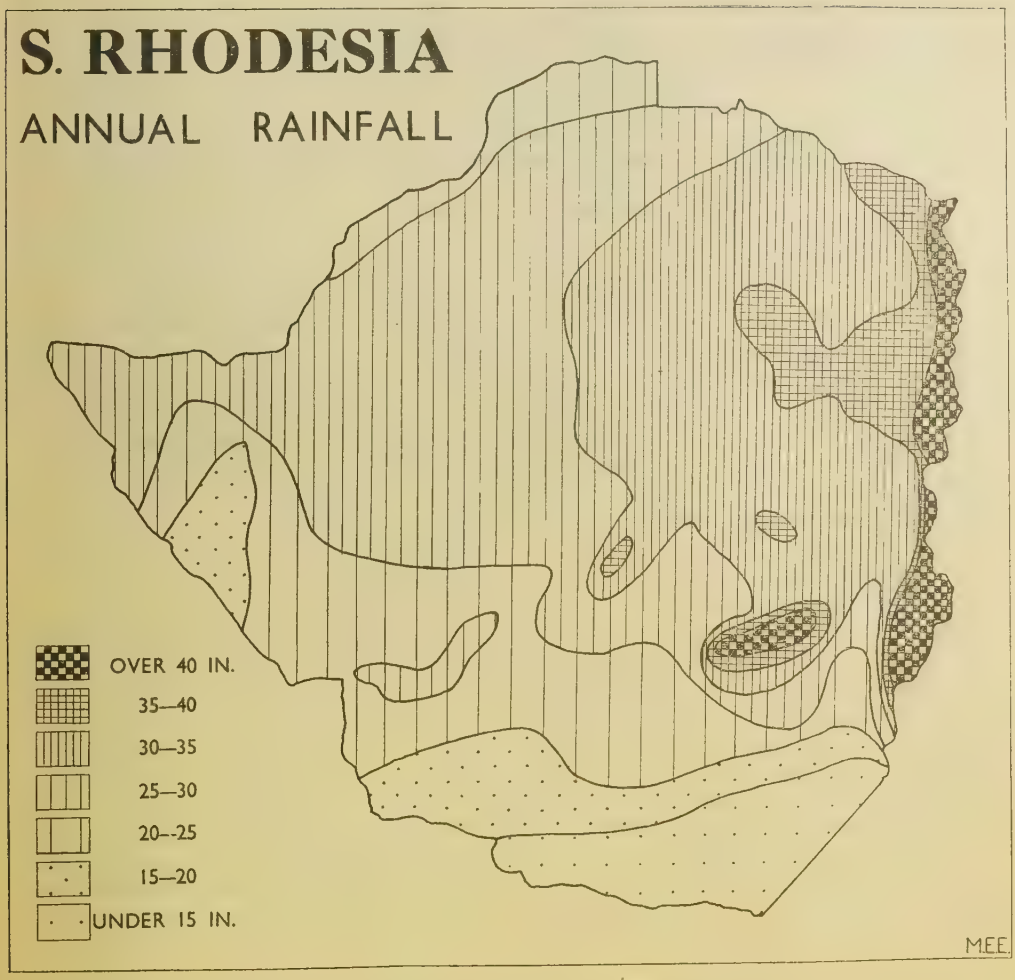
Mopani, characterized by *Copaifera mopane*, occupies most of the low veld. There is a broad block along the Limpopo in the southern end of the Province and another narrower belt along the Zambesi in the north.

Mangwe, characterized by *Terminalia sericea* and by *Burkea africana*, occupies most of the granite sand veld on the high Central Plateau.

Thorn veld, characterized by various *Acacia* spp., is sporadically distributed, occupying areas where formerly dense populations destroyed the then existing vegetation.

Umgusu, characterized by the Rhodesian teak (*Baikiaea plurijuga*), occupies the Kalahari sand areas in the north-eastern part of the Province.

* See footnote p. 10.



Msasa, characterized by *Brachystegia randii*, and mfuti, characterized by *Brachystegia woodiana*, cover extensive tracts in the north-eastern Sebungwe and Bubi Districts.

Central Veld and Pasture Research Station for Matabeleland

The Central Veld and Pasture Station for Matabeleland is located on the Rhodes Matopo Estate, which lies almost immediately to the south of Bulawayo at an altitude of about 4500 feet and in the 20 to 25 inch rainfall belt. The climate is, therefore, definitely semi-arid with a summer rainfall and an 8 to 9 month dry season. Frosts are frequent in the winter months.

Two distinct veld types are represented on the Rhodes Matopo Estate.

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READING UNIVERSITY
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The Sweet Mixed Veld or Thorn Veld (Henkel, 1931)*. Here the underlying rocks belong to the Basement schists and the soils are fertile red or grey loams with patches of black soils. (The thorn veld also includes an area of sand of the Kalahari system at the north-eastern corner of the Estate.) This region formerly carried a heavy native population and must have been almost completely cleared and extensively cultivated. It has been subjected to widespread and continuous disturbance by :

a. the past native occupants ;
b. European farming ;
c. the timber-cutting, road-making, and other activities of mining enterprises with which it is liberally supplied.

The vegetation is largely secondary and consists principally of *Acacia* species. *Acacia karroo, A. benthamii, A. rehmanniana* and *Dichrostachys glomerata* are common. The density of the thorn varies considerably from open tree veld to dense thicket. Many other trees occur in the thorn veld as occasional or relict species and are often dominant in less disturbed sites, such as, rocky hills and in broken country, where the topography or shallow soils have discouraged cultivation. The following are important :

Peltophorum africanum,
Combretum spp.,
Zizyphus mucronata,
Bolusanthus speciosus,
Heeria insignis,
Rhus spp.,
Sclerocarya caffra,
Diplorrhyncus mossambicensis (in some localities).

In this veld the grasses are well-developed, and the relative status of the numerous grassland communities is being investigated.

Heteropogon contortus, Hyparrhenia spp., *Cymbopogon* spp., *Themeda triandra, Setaria* spp., *Amphilophis insculpta, Brachiaria* spp., and *Digitaria* spp., are important in the " undisturbed veld".

The thorn veld provides comparatively good winter grazing and where both Mangwe and thorn veld are available, stock are wintered on the thorn veld.

Sour Mixed Veld or Mangwe Veld (Henkel, 1931). Here the underlying rocks are granite and the soils are poor and usually acid sands. The valleys and flat lands have been subjected to extensive disturbance by clearing and cultivation in the past. The hills are largely bare rock or covered with very shallow soils. There is no mining.

The vegetation varies from " tree veld " to moderately dense bush. Much of the flat land has been cleared and is grass-covered, often sparsely studded with trees. The following trees are important :

Terminalia sericea,
Burkea africana,
Pterocarpus angolensis,
P. rotundifolium,
Combretum spp.,
Peltophorum africanum,
Ficus spp.,
Dombeya rotundifolia,
Heeria insignis,
Bolusanthus speciosus,
Kirkia acuminata,
Albizzia spp.,
Commiphora spp.,
Copaifera mopane (pockets in poorly drained areas).

* Henkel, J. S., " Types of Vegetation in S. Rhodesia." *Proc. Rhod. sci. Ass.*, Vol. 30. 1931.

The grasses are important where the tree vegetation is more open, and, as in the thorn veld, there are numerous communities.

Characteristic plants in the " undisturbed veld " are :

Hyparrhenia spp.,
Cymbopogon spp.,
Heteropogon contortus,
Andropogon spp.,
Elyonurus sp.,
Digitaria spp.,
Pogonarthria squarrosa,
Schizachyrium jeffresii,
Crossotropis grandiglumis,
Trichopteryx simplex,
Perotis indica.

Winter grazing in the Mangwe is very poor and cattle are wintered in the adjoining thorn veld when possible.

Research Programme

A comprehensive programme of research has been drawn up, in which rather more than 1000 acres of each veld type will be used for experimentation. Briefly, the main objects of the work will be to obtain the necessary information on which to base farming systems, so these can be in harmony with the environment. Attempts to fit the land to unsuitable systems lead to eventual destruction and disaster, despite any temporary economic benefits which may be obtained. Space will allow of only a brief outline of the individual experiments.

Ecological Survey of the Area. The natural vegetation of any area is the product of its environment and is, if correctly interpreted, the best indicator of proper land use. It is the function of veld and pasture research to make a detailed study of the vegetation, to classify it into ecological types and sub-types, and to investigate the possibilities and best use of each vegetation type area.

As the information provided by this type of research is absolutely essential for the working out of correct farming systems and for the avoidance of malpractices, it follows that the first aims of the Central Veld and Pasture Station must embrace an ecological survey of the area it serves. The survey will delimit the various vegetation type areas and the possibilities of these areas will then be investigated from strategically located sub-stations controlled by the Central Veld and Pasture Station. Within each type an intensive study of the vegetation must be made to determine its reaction to use and its potentialities.

Plant Succession. This will necessitate a careful study of the plant succession in order to understand the effect of the treatments applied and the selection of the most stable, least easily damaged and most productive stage for use. It will show how best to attain and maintain this stage.

Grazing Management. The principles of grazing management within each type require study by large-scale practical grazing experiments in order to evolve simple, easily understood grazing systems capable of general application and designed to afford the maximum grazing capacity, while maintaining the veld in good condition, at its most suitable stage. This will involve detailed studies of the effects of burning and mowing, the duration and season of resting, the value and optimum density of trees, the methods and cost of bush clearing and the prevention of scrub encroachment, the combating of destructive termites and the eradication of poisonous plants.

In considering the problems of grazing management and their investigation, it is

important to remember that much work has already been done and that certain broad principles of general application are already fairly well understood. In laying down experiments designed to attack the problems peculiar to this particular area, time and effort will be saved by taking advantage of present knowledge.

(a) *The purpose of grazing management* is to carry as many head of stock as possible and to provide adequately for them throughout the year while maintaining the veld at the stage at which it provides the maximum amount of high-quality forage and is most resistant to bush encroachment and to erosion. The stage in the plant succession which approximates most closely to this ideal will be determined by succession studies and other ecological investigations, which will proceed simultaneously with the grazing investigations.

When the best stage has been decided, it will then be possible to know the best method of achieving it. In the meantime, it is generally acknowledged that the " undisturbed veld " or fire sub-climax composed of perennial species fairly high in the grassland succession, adapted to an uncertain rainfall and maintained by periodic burning, is with very few exceptions the most desirable type of indigenous grassland, and grazing management generally will be directed towards the maintenance of this stage.

(b) *Mowing and burning.* In the mixed veld types under consideration, where the palatability of the constituent species varies considerably and where both palatability and feeding value decrease rapidly as the grass matures, it is not possible to obtain full utilization of the veld by the grazing animal. It has been shown that in these veld types it is often necessary to use mowing or burning to make the pasture uniform in height, and to offset the effects of selective grazing. Attempts to obtain the same effects by increasing the grazing pressure until the veld is grazed down completely invariably have a very bad effect on :—(1) the grazing animal, which exhibits a rapid reduction in growth rate and loss of condition ; and (2) the veld, leading to symptoms of severe overgrazing, the replacement of the more desirable perennial grasses by less desirable pioneer types and ultimately to denudation followed by severe erosion.

In mixed veld where the danger of bush encroachment is always present, periodic mowing or burning seems essential not only for the maintenance of a grazing sward, but also for the control of bush encroachment.

Mowing is obviously the best form of veld control and there is much that can be said in its favour ; for various reasons, however, topography, terrain, size of farm, presence of tree growth, etc., it is impossible to mow and the grazier is forced to resort to fire.

Where it is not possible to mow, it can safely be said that the intelligent use of controlled burning at the correct time and in combination with after-burn resting seems essential in the management of mixed veld. It has been shown that the best results are obtained from burns made at the close of the dry season, that is, after the first good rains have fallen and before the grass begins to grow.

This technique will be followed in all management experiments which include burning, but at the same time the effect of fire on the local vegetation will be studied in separate experiments and it is possible that the results obtained from the " burning " experiments will in time be used to modify or alter the burning technique used in the management of grazing.

(c) *Grazing systems.* The principle enunciated by Sir George Stapledon in the following words :—

> " Swards will recover from the most villainous malpractices, if such malpractices are not too long continued, and if they are not put into practice at exactly the same time each year, year after year "

is as true in the management of mixed veld as it is in the management of perennial grassland anywhere. Management must be based on a realization that rotation is essential and it must be a rotation in time as well as in space.

A deferred seasonal rotation fulfils this essential condition while at the same time making it possible to incorporate burning or mowing as well as periods of rest in the system of management. Rotational systems, devised for the intensive management of highly productive pastures in countries where the rainfall is high and well-distributed are not applicable here, where the level of production varies widely under the influence of an erratic rainfall.

Systems involving continuous grazing of the same veld year after year and fixed seasonal rotations where the same areas are grazed at the same time each year are not only wrong in principle, but have been shown to lead to progressive deterioration of all or part of the veld so grazed.

Fodder Conservation. In a country where some 8 of the 12 months in each year are normally dry, the problems of fodder conservation urgently demand investigation. The production of veld hay and silage, the production of supplementary fodder from arable land, the selection and trial of legumes, grasses and other fodder plants, and the value of trees and shrubs both indigenous and exotic as providers of fodder are important lines of investigation.

Maintenance of Stock in the Dry Season. The maintenance of stock during the long dry season requires investigation on the use of :

(a) the veld alone ;
(b) veld hay ;
(c) veld hay plus supplements grown on arable land.

This investigation will provide information about the amount of arable land and hay meadow required in relation to the size of the area reserved for summer grazing.

Reclamation. The effects of the misuse of land, bush encroachment, denudation, sheet and donga erosion, etc., are widespread. They must be studied and means for curing the damage and restoring the vegetation have to be devised. This entails a study of methods of scrub clearing and the selection of suitable plants for revegetating denuded and eroded areas, as well as contour banks, ridges, pasture furrows and other intentionally disturbed areas, etc., and will necessitate the large-scale production of suitable plants and seed for use in this work.

The Efficiency of the Rainfall and the Water Relations of the Vegetation. Research projects dealing with the efficiency and utilization of the rainfall are of primary importance. It will be necessary to study :

(a) the correlation between rainfall and run-off under various conditions and vegetal cover, slope and treatment ;
(b) the water content (Holard) of the soil at various depths and in different communities and to compare these findings with the rainfall ;
(c) the evaporation under different types of vegetal cover ;

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(d) the water relations and amount of water used by the more important plants and plant communities ;
(e) the efficiency of practices intended to prevent run-off ;
(f) the proper use and care of catchment areas, stream-beds and banks, vlei and sponge areas, etc.

Planted Pastures and Seed Production. The importance of the grass ley in an arable rotation for maintaining soil structure, together with the obvious difficulty of establishing temporary or long-term leys under semi-arid conditions, renders research into the establishment, management and economics of planted pastures very necessary. Suitable pasture and hay grasses and legumes for both dryland and irrigated pastures are needed and the very strong possibility that the most suitable species will be found in the native flora must be borne in mind.

A thorough investigation of the behaviour of all promising native grasses and legumes for cultivation is essential. Suitable varieties for pasture, hay, green fodder, reclamation work, etc., will be selected and propagated. Their seeding habits and germination require investigation. The technique of seed harvesting necessary for the large-scale production of seed will have to be developed.

General Experimental Technique

Grazing Management Experiments

The seasons of the year defined. Because of the erratic fluctuations of climate, it is impossible to establish definite dates for the commencement and end of particular seasons. Therefore for the management of these experiments, the seasons are defined as follows :—

Summer is the period of vigorous growth and high rainfall. It lasts approximately from the middle of December to the middle of April.

Autumn is the dry end of summer. It commences when, because of lack of rain, growth slows down and the grasses begin to dry, and lasts until the commencement of regular frosts, that is, approximately from the middle of April to the middle of May.

Winter is the season of fairly regular frosts when the grasses are dormant, approximately from the middle of May to the middle of August.

Spring begins when early grasses, trees, etc., begin to shoot in response to increased temperature. It lasts until the summer rains begin. The period is approximately from the middle of August to the middle of December.

Spring is the most critical period of the year. Scattered showers to be expected from about October onwards cause a certain amount of greening. Cattle lose their taste for dry food and their growth curve usually shows the sharpest decrease during the end of the dry spring period, that is, from October until the beginning of summer (the rainy season).

A division of the year into summer and winter, to correspond with the wet and dry seasons, is sufficient for most purposes.

Burning. In all grazing experiments which include burning, the burn is made after the first good rain and before there is much growth. Burnt areas are always rested for a considerable time before being grazed.

Mowing. In the grazing management experiments, where mowing is used

primarily to control the veld and to control bush encroachment, the veld is mowed when the maximum yield consistent with quality hay can be obtained, that is, towards the end of the growing season, but before the grasses are dry. Only one cut is taken.

The Grazing Animal. In all grazing experiments the effect of the different treatments is compared by their effect on : (a) the animals, and (b) the veld.

It is proposed to use groups of ten animals on the management experiments. This size of group is considered large enough to eliminate error from individual differences and to make possible a statistical comparison of results. Grade beef yearlings (±15 months) of uniform type and known history have been bought for the experiments.

The animals will be divided into groups of ten, according to age, weight, height and uniformity. The grouping will be vertical to ensure a similar variation within each group. They will be kept on the experiments for 2 to 3 years, so as to come within the Standard A Grade beef when slaughtered.

Marking. In order to facilitate the keeping of records, animals will be marked in the following manner :—

Brand—Experiment number on near shoulder.
Tattoo—Individual number on off ear.
Ear Tag—Individual number on near ear.

Records. During their time on the grazing management experiments, the following records will be kept :—

a. weight every 2 weeks (cattle to be kraaled during the night and weighed the next morning) ;
b. girth and height measurements every 2 months ;
c. block grade at slaughtering ;
d. record of health with periodic notes on condition, etc., supplemented by photographs.

Botanical Analysis. At the commencement of an experiment, the area will be carefully mapped and at selected points blocks will be located, permanently marked and analysed by means of the Bruce-Levy point quadrat. This analysis will be repeated at appropriate intervals depending on the speed of change in species composition or basal cover. Where necessary percentage area determinations will be made by estimation or charting in permanently located square metre quadrats.

Phenological observations will be recorded constantly and photographs taken to supplement these records.

MASHONALAND

The province of Mashonaland occupies some 51,351,000 acres in the eastern half of the Colony. It contains the bulk of the high veld, but there are also considerable areas of middle veld and low veld. Marandellas is a district of Mashonaland lying between 18° and 19°S. latitude and 31° and 32°E. longitude, situated on the main central plateau at an altitude mostly between 4000 and 5000 feet. The Central Veld and Pasture Research Station lies on somewhat higher ground at an elevation of 5400 feet.

Soil. The main type of soil in Mashonaland is of a sandy nature derived from granites and gneisses, and extending over the greater part of the Province. Widely

distributed in patches and strips throughout the granite soil is a red clay soil usually of doleritic origin and of high fertility. In vlei areas, black soils are characteristically present and are sandy or clayey depending on the neighbouring rock formation. In the middle veld and low veld, pockets of alluvial soil very limited in extent are sometimes found.

Vegetation.* The following is a brief description of the vegetation types of Mashonaland. The vegetation of Southern Rhodesia may be said to fall into two main groups, woodland and grassland, and each of these may be divided again into further types depending chiefly on climate and soil.

Eastern Mountain Range. Along a 200-mile stretch of the eastern border of Mashonaland at altitudes of 5000 to 6000 ft. and upwards, and with a rainfall of between 40 and 70 inches occur two types which are found nowhere else in the country, mountain grassland and mountain forest. The former is characterized by a good cover of short grasses with *Themeda triandra*, *Hyparrhenia* spp., *Eragrostis* spp., and *Trichopteryx simplex* as the dominant grasses in association with numerous other species. The mountain forest is of the closed evergreen type which occurs in the mist-belt although not on very extensive areas.

High Veld. On the main plateau at altitudes of 4000 to 5000 feet and under a rainfall of 30 to 40 inches, several types of open woodland may be recognized which are characterized by the dominance of different species of trees. Probably the most widespread type is that known as Msasa tree veld with *Brachystegia randii* dominant, but often with *Isoberlinia globiflora* occurring just as frequently.

In the higher parts of the plateau, *Parinarium mobola* forms another type of woodland often in association with species of *Protea* and *Faurea*, and a third type may be recognized by the prevalence of *Uapaca kirkiana*. In the lower rainfall areas of the plateau (20 to 25 inches) Mangwe veld characterized by *Terminalia sericea* occurs. All the open woodland types are associations of trees and grasses ; when the trees are scattered about singly, it is difficult to decide whether the vegetation should be described as woodland or grassland. Large areas of grassland often occur where clearing has taken place, but these revert to woodland if undisturbed. A distinct type of valley grassland, however, known as vlei grassland or vleis, is characteristic of the granite country with a rainfall of over 30 inches per annum. Trees have not generally invaded these areas owing to the wetness of the soil and apparently also owing to the comparatively severe frosts which occur due to altitude and topography. Where the soil remains permanently waterlogged, sedges form a high proportion of the herbage. While these vlei areas occur at all elevations, they are a particularly striking feature of the high veld.

Middle Veld. On the upland country, that is, on the slopes leading to the main plateau and at altitudes from 2000 to 4000 feet, woodland or open forest types are again the most important features of the vegetation. Over wide areas of northern Mashonaland, Mfuti veld dominated by *Brachystegia woodiana* occurs in a warm dry belt below the Msasa veld zone, although this latter type also appears at lower al-

* The description of the vegetation types has been freely extracted from " Types of Vegetation in S. Rhodesia " by J. S. Henkel, *Proc. Rhod. sci. Ass.* Vol. 30. 1931; and the Report of the Commission to Enquire into the Conditions Prevailing in the Pasturage of the Colony, by I. B. Pole Evans, Jan. 1943.

titudes as well. A high veld type with a wide altitudinal range and also frequently found in the middle veld is the Mnondo veld (*Isoberlinia globiflora*). Small areas of thorn veld (*Acacia* spp.) also occur where the soil is of alluvial or derived from basic rocks and the rainfall is fairly low.

The grass herbage which occurs in association with these middle-veld woodland types provides some of the best natural grazing in Southern Rhodesia if tree densities are not too great. The grasses are often tall and coarse, but are generally sweeter and better in quality than those of the more heavily leached high-veld soils.

Low Veld. In the lower parts of Mashonaland, that is in the low veld, at altitudes mostly below 2000 feet and with a rainfall of less than 20 inches, Mopani veld is the dominant type. *Copaifera mopane* is the characteristic tree of this woodland type, often occurring as a pure stand. The baobab (*Adansonia digitata*) is a frequent associate of mopani. On the more sandy soils, *Combretum* spp. form a characteristic bush veld over fairly large areas. *Acacia* or thorn veld is again chiefly confined to the alluvial soils or soils derived from basic rocks. Mopani veld is usually associated with clayey soils and the ground cover is very sparse and subject to severe erosion. On the sandy soils the grass cover tends to be open and the plants tufted in character, while the alluvial soils frequently have a good cover of sweet grasses affording valuable winter grazing.

It may be convenient to refer briefly to the grassland types commonly known as sweet veld, mixed veld and sour veld. The sweet veld occurs in the drier and more fertile areas at low altitudes and generally consists of grasses which are both palatable and nutritious in the dry state, thus providing good winter as well as summer grazing. The sour veld occurs at much higher altitudes (such as the high veld of Mashonaland) with a high rainfall, and the grasses are really palatable only in the young state. Good natural grazing is therefore confined to the growing season. Mixed veld contains a proportion of both sweet and sour grasses in varying quantities and therefore provides grazing throughout the year.

Central Veld and Pasture Research Station for Mashonaland

The site chosen for the Central Pasture Research Station to serve Mashonaland is on the main Salisbury-Umtali road, 3 miles north-west of the village of Marandellas and 45 miles from Salisbury. Later it is intended to open four or five sub-stations to serve all the major veld types of the main soil-climate-vegetation zones of the Province.

A brief description of the climate, soils and vegetation of the central station is given below.

Climate. The station falls within the 35 to 40 inch rainfall areas and has in fact had an average of 35 inches over the last 7 years. In some years as much as 46 inches may be recorded, while in 1941 only 18 inches fell. Light showers often fall in September and heavier precipitations in October, but the full rains with frequent thunderstorms usually set in only in November and continue until March, with light showers ending the rainy season in April. From May until September is regarded as the dry season, when frequent frosts are experienced. August, September and October are critical months so far as the provision of grazing is concerned. The mean temperature of the station is 61.5°F. with a mean maximum of 72.9° F. and mean

DEPARTMENT OF AGRICULTURAL BOTANY
READING UNIVERSITY
ENGLAND.

minimum of 52.6°F. and absolute means of 92° and 35°F. The hottest months are October and November and the coldest June and July.

Soils. For convenience the station may be divided into the dry or top-land areas and the wet or vlei areas. The top-land soil is a granite sand with a clay content of about 12 per cent, greyish white in colour and shallow in depth overlying a yellowish-brown sub-soil containing a higher percentage of clay. The vlei soils are black to a depth of about 9 inches, gritty due to the surrounding granite, and are appreciably more fertile than the top-land soil. Both types of soil are fairly acid (pH about 6 on the dry land and pH 5 in the vleis). As the station lies on the main watershed of the Colony, it is the source of several permanent streams and there are consequently extensive vlei areas. Some parts of these may remain wet through a normal dry season while others dry out to some extent during this period.

Vegetation. The top-land is typical Msasa tree veld characterized by patches of *Brachystegia randii* in association mainly with *Isoberlinia globiflora** in varying degrees of density ; it is fringed by grassland which forms a fairly good cover away from the tree areas but is sparse and attenuated in growth inside them. These fringes of grass occur between the tree veld and the vleis ; the percentage of sedges increases as the soil becomes wetter. Thatching-grass (*Hyparrhenia* spp.) is often the dominant type on the top-land soils in associations with russet-grass (*Trichopteryx simplex*) and several others.*

Perennial leguminous woody herbs such as *Eriosema* sp. and *Dolichos* sp. occur frequently except in the vleis, and their flowers afford valuable feed in the late dry season ; their herbage, however, is not eaten except to some extent in hay. Several areas of open grassland on the station have developed as a result of clearing for cultivation over a period of years, the abandoned land having reverted to grass. The vleis carry a dense herbaceous association of grasses, chiefly *Aristida* spp., *Brachiaria filifolia* and *Eragrostis brizoides*, with numerous sedges.** One of the broad-leaved sedges (*Scleria* sp.) is a good indicator of permanent wet vlei areas. In the drier parts of the vleis, the dominant grasses include many dryland species. In some vleis the dividing line between the areas where the sedges or grasses are dominant is very distinct.

Pasture Problems of the High Rainfall Sand Veld

The average farm on the granite sand veld areas is about 3000 acres in size, of which perhaps 200 to 300 acres are cultivated and the rest is left for grazing. The sand veld is not regarded as good arable land except for tobacco ; after tobacco, beef and dairy production are the most important lines of farming. Beef herds are usually small, being limited to the carrying capacity of the veld under current systems of grazing (one beast to 10 to 12 acres is perhaps a fair average). The greatest problem facing the farmer is to provide good grazing for his animals throughout the year.

* In association with *Hyparrhenia* and *Trichopteryx* are *Pogonarthria squarrosa, Eragrostis chapelieri, E. chalcantha, E. sclerantha, Trachypogon plumosus, Chloridion cameronii, Craspedorachis rhodesiana, Schizachyrium semiberbe, Trichoneura grandiglumis, Heteropogon contortus* and *Andropogon* sp. probably *A. schinzii*. Sweet grass such as *Digitaria gazensis, Brachiaria brizantha* and *Rhynchelytrum* spp. also occur but less frequently, with also several Cyperaceae.

** Common Cyperaceae in the vleis :—*Bulbostylis capillaris, Fimbristylis exilis, Cyperus tenax, C. compactus, Scleria* sp. and *Mariscus* sp. Other common vlei grasses are *Monocymbium ceresiiforme* and *Andropogon eucomus*.

When once the rains start the growth of grass is rapid and far more feed of high quality is available than the cattle can utilize. Abundant feed is thus available for the five summer months, but when the sour veld grasses mature they rapidly become unpalatable and produce very inferior grazing well below maintenance requirements until growth commences again the following season. Dairy farmers grow winter feed for their stock, but beef herds for the most part are generally left to fend for themselves during the dry season, with the addition only of a small quantity of maize stover and inferior veld hay cut after the rains are over. Fattening of slaughter stock is exceptional, and beef animals are generally sold off the veld when about 4 to 6 years old depending on the breed. Grazing for the latter part of the dry season is supplemented by burning the vleis every year or two towards the end of July or August and using the green flush which is produced 3 to 4 weeks later. If burning is carried out any sooner, frosts may kill off the young shoots and the grazing is lost. In the past, paddocking has hardly been economical and the cattle are run on free range. There is no system of rotational grazing on a deferred plan. Indeed, if any rotation is carried out it is of the non-deferred type, the same areas being set aside for grazing at the same time every year. Veld hay is cut as a winter supplement by an increasing number of farmers, but yields are low and quality usually poor, as heavy rains may spoil it, and the correct time for cutting clashes with other agricultural practices. When hay is made it is generally cut in April/May when the grass is long past its best.

The question of providing more satisfactory grazing on a yearlong basis therefore constitutes a major problem, and forms one of the main objects of the research programme. It is clear that the potentialities of the Msasa veld are not clearly known, as the question often arises as to what extent tree veld should be cleared to permit the best development of grass. That much greater production of herbage does occur after removal of trees is a well-established fact, but how this increased quantity of grass should be utilized to obtain its full value and the optimal ratio of grass to trees are questions still requiring elucidation. It may perhaps be better and more economical to thin out only sufficient trees to facilitate mowing and to allow the grass to be used to the full for summer grazing ; then to rely more on the trees and shrubs for browsing during the critical months in the dry season. The value of browse from trees and shrubs, however, requires critical study. Deferred rotational systems of grazing on this type of sour veld, using Msasa veld for summer grazing and vlei areas for winter grazing, obviously need investigation in view of the lack of any system in current cattle-farming practices. Although the cutting of hay in large quantities is not a standard practice, many of those who do carry out this operation cut the same piece of land year after year, and it would appear necessary to investigate the possible effects of such a treatment on the vegetation. The same may be said in regard to the question of veld burning.

The higher fertility and favourable moisture conditions of the vlei areas suggest that they could be more fully utilized during the dry season. The natural vegetation of the vleis is very unpalatable, consisting of wiry grasses and sedges ; it is only for a few weeks after burning that the new flush is relished by stock. The present system of frequent burning of the vleis, when the fear of frosts is over, may be harmful both to the vegetation and the soil.

Desiccation accompanied by the destruction of a certain amount of organic matter every year must inevitably impoverish the soil and may lead to the drying up

of the vleis and subsequent erosion. The establishment of permanent pastures of good grasses in these areas and their management therefore needs investigation. At the same time methods of conserving the soil moisture of the vleis with a view to enlarging them should be studied so that these natural assets can be turned to good account.

Research Programme

There are, as already stated, two main types of veld on the Station, the Msasa woodland or tree veld on the well-drained higher land and the vlei grassland of the valley bottoms and slopes where seasonal waterlogged conditions occur. A rough estimate is that two-thirds of the grazing is of the former type and one-third of the latter.

A comprehensive programme of research has been drawn up in which about 1000 acres will be used for intensive experimentation. The main lines of investigation in the twenty-four experimental projects which have been designed may be grouped under the following headings.

Ecological Surveys. As one of the main functions of veld and pasture research is to make an intensive study of the vegetation, an essential preliminary will be a detailed botanical survey of the research station. This work will then be extended to include the mapping of the various ecological types and subtypes occurring in Mashonaland, and intensive studies of the various vegetation types and their reaction to treatment will be carried out at sub-stations in conveniently situated localities.

Utilization and Management of Natural Veld. Our present knowledge of the potentialities of the natural veld is extremely limited ; the most important aspect of this research programme will therefore be a thorough investigation of the principles of grazing management so as to be able to ensure maximium grazing capacity while maintaining the veld in good condition.

In order to assess the carrying capacity of the veld under different systems of management, numerous grazing trials involving burning and mowing as well as varying intensities of grazing will be carried out and the behaviour of the veld under these different treatments will be studied. The time and duration of rest periods will be investigated in order to assess their relation to the productivity and quality of the herbage. The optimal tree spacing for pasture production and the value of browse afforded by trees and shrubs are to be studied as well as methods of tree, scrub and weed eradication.

The promising potentialities of the vlei areas as a source of autumn, winter and spring grazing will receive particular attention in view of the large areas which they occupy on so many farms.

Established Pastures. The possibility of establishing more productive pastures of suitable species on both dryland and in the vlei areas and their responses to manures and fertilizers, including trace elements, will be throughly investigated. The management of these pastures and the part they can play in a yearlong system of grazing will receive careful attention.

On the dryland areas a study will be made of the value of sown pastures as compared with natural regrassing in their effect on soil structure and fertility in crop rotations.

Veld Burning. Although veld burning is a form of veld management, the

problem is of such importance as to warrant a separate series of experiments. The time and frequency of burning of both dryland and vlei areas will be the main lines of investigation in this section. The influence on the vegetation and soil of burning with and without grazing is still a subject of much controversy, and requires careful study.

Soil and Water Conservation. Under this head, studies are to be made of the comparative run-off and soil lost with different types of vegetal cover and treatment. Rainfall percolation and soil moisture studies under different types of cover will also be made. An important feature will be an investigation into the treatment of catchment areas with a view to increasing the area of vlei-land and maintaining favourable moisture conditions throughout the dry season.

Nursery Work. Introduction and trial of promising exotic and indigenous fodder, pasture and soil-protecting species will be made, and methods of propagation and seed production studied. Provision will be made for seed increase plots for the establishment of pastures on a larger scale. Demonstration plots of local grasses and plants, including those known or suspected to be poisonous, will be laid down.

General Ecological Investigations. Studies of the natural succession in the different types of vegetation will be made and the significance of indicator plants and plant communities determined with particular reference to grazing management. Phenological notes will be made throughout the experimental work.

Experimental Technique

Design. Since the programme is of necessity largely exploratory in the early stages, it is hoped to eliminate certain of the treatments after a few years and then to concentrate on those which show the most promising results. Since pasture utilization in Southern Rhodesia has not yet reached the stage of development where very small differences in productivity are important, it has been decided to regard a large number of the experiments as observation plots, and to look for treatment responses visibly significant and obviously of practical importance. When those treatments meriting further investigation have been selected, suitable design will be introduced to allow statistical interpretation of the data.

Sufficient elasticity in experimental methods is provided to allow for development and modification of design, lay-out, rate of stocking, etc., as may be considered necessary.

Methods. The following methods will be used to measure pasture and animal production within the scope of the present programme.

Herbage Yields. Where yield cuts are required for measuring herbage production the samples will be taken at about 3-weekly intervals or just before grazing in the case of grazing treatments. The area sampled in each plot will eventually be determined by the variation shown in the sub-samples which make up the total composite sample. In the case of grazing treatments, sampled areas are protected by means of wire cages. Six samples are taken to make up yield cuts, and the cages are moved across the plot from one sample area to the next, along permanently marked strips. When a sample has been taken, the area for the next position of the cage is prepared by cutting at the same time, and the cage is then placed in the new position.

The samples are dried, weighed and, where required, a representative sample is taken for chemical analysis.

Botanical Analysis. The Bruce Levy point quadrat method and the line transect method will be used to record botanical changes and composition.

Liveweight changes and grazing days. When pastures are to be compared, the most satisfactory standard of evaluation is a combination of liveweight changes and grazing days, since animals may subsist for a long period on one type of grazing and make only small gains, while equal gains may be obtained in a shorter period on another type. In order to compare the actual grazing value of two pastures, gains and grazing days may be converted to starch equivalent value or therms per unit area, and comparisons thus made on a common basis.

In each experimental unit, ten immature grade steers will be used. The cattle will be weighed fortnightly—watered the previous evening, kraaled without food that night, and weighed in the morning.

Photographs. Photographic records of the pastures from fixed points and of livestock will be kept to illustrate any striking botanical changes, botanical types, and condition of cattle.

THE ECONOMICS OF LEY FARMING*

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Amongst other changes in farming we alter the names and descriptions of things and systems without making much change in the subjects. Another description of ley farming, for example, has been alternate husbandry. Perhaps a new meaning is being given to the idea of ley farming when the description is applied to a system of producing pastures, or pastures and hay in a continued process of renewal by direct reseeding. The new conception of the process is the renewal of grass after grass, omitting what have been the intervening arable crops. Whether this process will eventually be established as an accepted part of farming practice only experience can prove, and forecasting may be dangerous.

In the earlier and indeed very old form of alternate husbandry—the rotation of leys with tillage crops—the system had many purposes. Amongst these were the maintenance of condition and fertility of soil, and the production of hay and pastures. The hay might be provided largely for work stock, for cattle-feeding in yards, and for sheep, particularly in the predominantly arable areas. But it was produced partly for off-farm sale and also for other types of live stock. Over the country as a whole some 60 to 66 per cent of the leys (clover, grasses and mixtures) has been mown for hay. In some areas, as in Norfolk, 80 per cent or more has been regularly so used. On the other hand, there are areas in Cornwall, Devon, Breconshire, the East Riding of Yorkshire, among others, in which farmers have used the greater part of their ley areas for pasturage. The production of leys mainly for pasturage is certainly not new, although it has not been general.

In different parts of the country and under varying circumstances the leys have been laid down to last between one or two and eight to ten years. The shorter forms were primarily processes in the maintenance of arable production, while the longer forms were processes in the maintenance of good swards for the production of pasturage and hay. Production of hay has always been important. With some marked local variations, as indicated above, about 64 per cent of the leys, about 30 per cent of permanent swards, and about one-third of the total cultivated grass area of this country have been mown each year. These proportions show little variation from year to year, or even over long periods. There are no present indications of marked change in this position. If the new system of ley farming is to spread, the new type of leys must carry their share of the hay crop or more hay must be taken from the permanent swards. Under the older ley systems, designed largely for hay production, at least in their first or early years, yields of hay have been higher than those obtained from permanent swards.

If farmers who have used leys had been more concerned with getting hay than with the maintenance of fertility for arable crops, or with maintenance of good swards, it appears practically certain that they would have produced more hay from per-

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DEPARTMENT OF AGRICULTURAL BOTANY
READING UNIVERSITY
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manent grass and less from leys. While there are some costs of hay from rotation grasses which are lower than those of hay from permanent swards, the present tendency is towards higher costs on the leys. But in choosing to use rotation grasses and clovers for making hay rather than for spring and summer grazing, farmers in most districts appear to have been wise. As far as can be ascertained from the records available, the relative economy of using leys for hay has been higher than that of using them for grazing. This condition has arisen partly from the seeds mixtures hitherto used and possibly from the seeds commonly available.

The recent emphasis in ley farming has been on production of pasturage. If the system of renewal by continued reseeding is to become anything like universal over a farm or an area, it may have to take two forms—one designed to produce pastures, the other for hay. The alternatives seem to be those of using the pasturage type of new sward to produce herbage for silage making or grass drying. The former of these, though practised successfully by a minority of farmers, has never become popular ; the latter has been commercially exploited in production for sale, but it has been adopted for farm use in only a very few cases.

Effect of Mechanical Power

There are indications that the importance of leys in more purely arable systems of farming may diminish. Substitution of mechanical for equine power causes a smaller requirement of hay for work stock. The increased supply and use of mechanical power has not removed as many horses as might have been expected, but any increase in economic pressure and in need of economies may complete or more nearly complete the process of substitution. In that case, unless the ley areas are contracted, new markets or uses must be found for clover and other rotation hay hitherto produced for horses. Such new uses may be increased use for feeding cattle, or substitution of milking herds for fattening stock but they are not likely to be found to any appreciable extent in feeding sheep. On the contrary, the requirement of hay for arable sheep flocks may fall. But there is at least the theoretical possibility that more of the leys in arable systems may be used for pasturage. Practice in certain districts indicates that this is feasible under some circumstances.

Maintaining Soil Condition on Arable Farms

Whether arable farmers can maintain their soils in productive condition with smaller proportion of leys than they have had in the past, or without leys, depends partly on local circumstances, but partly on possible modifications in a whole series of processes in cultivations, and in use of straw and fertilizers. Whether, on the other hand, farmers who adopt the new system of ley farming, seeding and reseeding mainly for pasturage, can continue the process without using grain or other arable crops between their grass crops, remains to be proved by experience. There are two aspects of this case : the technical and the economic. From a limited experience it appears that good swards can be made and remade, and there are no obvious grounds for doubt that the process may not be continuously successful. But a process which may be technically possible may not prove economical. It has always been held that pastures, particularly those well stocked with clovers, store fertility. Production of pasturage by reseeding usually involves, if it does not require, much more liberal use of fertilizers than production of permanent swards. It is generally claimed that

the ley pastures carry much more stock than the permanent. Therefore it appears that the reseeded pastures should store fertility much more rapidly than the old type. If this is the position, and arable crops are not to be used to pick up and 'cash-in' the fertility, the question must arise as to what is to happen to it? Where farmers have used long leys largely for pasturage, and for the purpose of making good swards, they have usually taken two to four arable crops between the leys. It is now suggested that questions of economy of capital investment and the maintenance of cultivation, seeding and harvesting implements, and machinery for relatively small areas of arable crops arise in this connexion. No one has made a close study of the relative economy of maintaining mixed farming equipment and that of letting fertility flow down to the seas or of overstocking pastures with fertility. While there has been sad experience of overstocking pastures with fertility, particularly by intensive feeding of concentrates to dairy herds, there has not yet been any proof that the farmers who used short arable rotations between the longer leys were following an uneconomical system.

But technical conditions alone never determine the uses or the forms of leys. Regarding them from the arable point of view, whether of continuous arable with short leys, or of short tillage breaks between long leys, the position has been that when grain prices were low farmers laid more land down or the existing leys were kept down for longer periods, and when grain prices improved the reverse policy was followed. Looking at leys from the point of view of producing pasturage and hay, more particularly the former, the simple position has always been that grass was the cheapest form of feed for grazing animals. It was cheap because the main factors in production on permanent swards were of natural character—soil and climate. Labour power, fertilizers, seeds, were much less important factors than in crop production. General management, and live-stock management, were important, but they did not appear as direct cost factors.

Grass as a Crop

In the treatment of grass as a crop there are several conditions which are new, or relatively new, and of rising importance:

1. Mechanical cultivations—reducing costs and particularly manual labour costs, but also extending the area of cultivations which can be handled by a given farm staff;
2. Increase in knowledge of plants for pasture and hay production, and the provision of better strains of plants for specific purposes;
3. Increasing application of the older knowledge of uses of lime and phosphates in sward production, with larger and cheaper supplies;
4. Shortage of imported feeding-stuffs, particularly those of medium and high protein character, and the general need of providing more live-stock feed on our own farms.

The first two conditions will remain and may become even more favourable to the ley farming system. The third condition may be expected to remain while the others continue to be favourable. Continuance of the last condition is uncertain. And it must be said that if we are growing grass and legumes for winter protein supply we have not yet found entirely adequate and satisfactory ways of using them. For this purpose we need better practices, or the extension of the better practices of hay-

making, but almost certainly we shall need more silage making or more grass drying for ordinary farm uses.

There are, however, other economic conditions which are of extreme importance. In times of normal or lower profitableness of farming, the enterprising or progressive farmers who are making individual economic advances, and want to extend their business, look for additional land or larger farms. When nearly every farmer is making good profits, when most farmers' sons are looking to following their fathers, this mode of extension is restricted. Farmers who wish to increase the size of their business must look for opportunities of intensification of production rather than extension of areas. With a rising price level and profit margins, increasing production by intensification will be justified. With pressure to maintain and opportunities of profits from live stock on one side, and increasing opportunities of profitable sale of arable crops on the other, the interest in the ley system of pasture production is not surprising. Continuation of this interest depends partly on the continuance of these conditions, and then partly on possibilities of reducing costs and obtaining certainty of success in the production of swards by direct seeding and reseeding.

Some General Costings

At present there appears to be little doubt that production of pasturage under ley farming is somewhat more expensive than on good permanent swards. But this is not to say that leys are uneconomical or that the process of making them is not financially justified. Many farmers who have used them for maintaining or increasing their live stock while taking opportunities of selling crops have undoubtedly obtained financial benefit.

When the Ministry of Agriculture undertook some propaganda in favour of reseeding in 1942 it published these 'average' costs of ploughing and reseeding direct from grass.

	Per acre. £ s. d.
Ploughing and cultivations	3 0 0
Lime (1 ton at £2 *less* subsidy)	1 0 0
Phosphate fertilizer	1 0 0
Seeds mixture	2 10 0
Total outlay	7 10 0
Less ploughing-out subsidy	2 0 0
Net cost to farmer	£5 10 0

There are records of total costs of reseeding ranging between £4 and £16 per acre, but general costings indicate that the gross cost is more likely to be £10, with ranges somewhat as follows :—

	£ s. d.		£ s. d.
Cultivation and seeding	3 0 0	to	4 10 0
Lime and fertilizers	3 0 0	to	4 0 0
Seeds	2 10 0	to	3 0 0
Total cost	£8 10 0	to	£11 10 0

Exactly how much has to be allowed for seeding failures, for loss on work done,

materials used, and loss of use of land has not been determined. There are records of one failure in five, but the average is probably lower.

Costs of pasturage for cows in Yorkshire, 1914 to 1929, ranged between 38s. an acre in 1914 and 69s. in 1919, and averaged about 50s. an acre for the years 1922 to 1929. There are records of costs of 'Valley' pastures in Kent of about 40s. an acre, between 1933 and 1938. A Welsh study of pasturage costs for dairy herds between 1935 and 1938 showed similar average costs at 39s. an acre. A recent study of costs of pasturage for dairy cows in the Eastern Counties showed a range from below 20s. to over 50s., with an average of 39s. 8d. an acre in 1942-3. Recent Welsh studies of costs of pasturages for cattle feeding showed a range between 30s. and nearly 80s. with an average of 51s. 6d. in 1942, somewhat wider ranges in 1943 and 1944, but with higher and lower averages at 54s. 3d. and 49s. 5d.

Assuming a life of 4 years for the reseeded pasture, a sample comparison between good and relatively expensive permanent pastures and reseeded leys will be along these lines.

	Permanent Pasture	Reseeded
	£ s. d.	£ s. d.
Original cost of reseeding	—	10 0 0
Rent 4 years	6 0 0	6 0 0
Maintenance labour 4 years	3 0 0	2 0 0
Fertilizers 4 years	2 0 0	—
	11 0 0	18 0 0*
Cost per annum	2 15 0	4 10 0
Ratio	100	164

Yields from direct seeding and reseeding are variable. With the same seeds mixture and general treatment within a restricted area in one season there seem likely to be striking variations. In Warwickshire, in 1944, the variation for fifteen farms was between 129 and 512 cow-days during the period May to December. The average was 243 cow-days. There are also wide variations between carrying capacities of permanent pastures, arising from quality of land, treatment of swards, and weather conditions.

The most extensive and possibly the most reliable comparison of yields of reseeded and permanent pastures available appear to be those from Dartington Hall. Here a number of fields in each category were recorded over a 10 year period 1932 to 1940–41. The records for permanent pastures are necessarily more continuous than for the reseeded. But the grazing output of the reseeded was 45 per cent higher than for the permanent pastures. The variations were 22 per cent in 1933–4 on six reseeded against fourteen permanent fields; 28 per cent in 1931–2 and 1937–8; exceeding 60 per cent in three of the years, 1932–3, 1934–5 and 1935–6. The highest figure was 68 per cent.

Beyond the question of mere quantity of yield or of stock-carrying capacity, there is a question of seasonality of yield and of the value of 'early' and 'late bite.' Here the evidence seems to be conflicting. There is no doubt that in comparison with *poor* permanent swards the reseeded pastures yield both earlier and later pas-

* These costs of direct seeding may be reduced by the £2 ploughing grant if the farmer is lucky enough to have land which qualifies for it.

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ENGLAND.

turage. But the result of comparisons between *good* permanent swards and reseeded pastures is not yet entirely clear.

Intensification of Production

Further discussion of the economics of ley farming involves complex considerations. But as in the case of the short-term rotational leys, it appears that extension of direct seeding and reseeding will be highly dependent on the price level ; in this case, prices for live stock and their products. At present it seems that fairly extensive reseeding is likely to be justified in the case of pasturage for dairy cows. In the case of pasturage for feeding cattle, it may be justified in many instances. Extensive reseeding mainly for production of store cattle or sheep seems a doubtful enterprise. Yet there are many farms on second and third-class land on which direct seeding of a minor part of the pasture area will be justified when it not only increases general yield but extends the grazing period and provides young pasturage of relatively high protein value when other succulent or protein feeds are scarce.

A change-over from other systems of ley farming will almost certainly involve changes in the economic structure and organization of the farm, but may or may not substantially change the character of its output. It usually requires an increase in inputs of labour and materials and therefore frequently in capital. But where it enables the farmer to make fuller or more effective use of all, or some of the most important resources on the farm, it will reduce the overhead or general costs of land and labour per unit of product. (If on land rented at 20s. an acre and producing 100 gallons of milk the productivity is raised 50 per cent by reseeding, the *rent* cost of pasturage is reduced from 2.4d to 1.6d. per gallon. If the productivity of labour and equipment is raised 20 per cent the general labour cost per unit of product will fall by one-sixth.) This is particularly the case where the labour resources—manual and animal or mechanical—are already on the farms. The position may be quite different when a farmer has to pay directly for all cultivations, fertilizers and seeds. There is little doubt that intensification of production, and consequently increase in output, is possible on many farms in this country. As cropping for sale recedes it is desirable that live-stock enterprises should be extended.

Perhaps one word of warning is necessary to those who interpret the present tendency towards ley farming practice in grassland areas as indicating recognition of some inherent advantages of the system. In any period of rising prices there is likely to be some increase in the intensity of farming, or, to put it in another way, ' higher farming will pay.' Ley farming is certainly a higher farming system than permanent pasture, and the growth in the popularity of the system is in part at least only a manifestation of the desire to intensify production in response to favourable prices. But the adoption of higher farming practices may modify some of the basic physical conditions which are important in land usage as well as the economic organization of farms, and this may give the new system some degree of permanency even when the external influences change. A possible reaction towards the pre-existing system as a result of a new set of market influences, such as occurred after the last war, does not add or detract from the value of the system at the present time. This is only to say that ley farming is a system which can be followed with advantage in one set of economic conditions, but may not be applicable or desirable when these conditions change. Those who advocate or have practised ley farming need to look to methods of securing a high degree of certainty of success in direct seeding and reseeding and to methods of reducing costs.

THE PRESENT CENTRES OF INTENSIVE FORMATION OF PLANT SPECIES*

I. S. Travin

СОВРЕМЕННЫЕ ЦЕНТРЫ ИНТЕНСИВНОГО ВИДООБРАЗОВАНИЯ РАСТЕНИЙ

И. С. ТРАВИН

"In every place where many species develop, or, if it may be so expressed, in places where the formation of species has been successful, we generally find this formation still in action, the more so because we have every reason to suppose that this process of production of new species is achieved very slowly." (C. Darwin [4]) Therefore when examining the present geography of any plant genus we may safely assume that its species formation proceeds more intensively just in those regions in which the greatest quantity of species of the genus is concentrated. In different parts of the earth the flora is not alike. In some regions the number of species and genera is insignificant, in others very large; in some, the genera include but few species, in others a large number of them. In other words, in our present geological epoch the most intensive formation of plant species proceeds only in definite regions of the globe. These centres of contemporary species formation in plants are those parts of the earth's crust in which the occurrence of geological action, either in the recent past or at the present time, is very much in evidence. These areas are distributed not by chance, but usually coincide with the chief zones of faults in the earth's crust, and with contemporary geosynclines and geoanticlines. To a lesser degree they are found apart from them.** A comparison of the systematics and geography of wild and cultivated plants with maps of the present zones of intensive geological activity gives convincing evidence of the relation between the present centres of intensive geological action in the earth's crust and intensive species formation.

Let us begin with the examination of two families—grasses and legumes. These families are extremely important in agriculture, and contain species widespread over all the globe. Thus it is possible to encounter genera in extremely diverse regions of distribution from the tropics to the polar regions, and either within extremely wide or restricted areas.

From a study of all the tribes of the grass family, the regions of their distribution, the number of genera and species in each tribe (5), and determining the average number of species in one genus, we draw the following conclusions:

1. In tropical and subtropical zones there is concentrated the greatest diversity in systematic classification of grass herbage. Of a total of 28 tribes, 563 genera and 6802 species, only 4 tribes (14.3 per cent) are not in the tropics. They are Nos. VII, VIII, XII and XVI, constituting 16 genera (12.9 per cent) and 396 species (15.8 per cent). [VII—Stipeae; VIII—Brachypodieae; XII—Nardeae; XVI—Lygeae].

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* Translation made by M. Hall [revised by I. Zacopanay] of article published in *Botaničeskii Žurnal, SSSR.* [*Ботанический Журнал, СССР.*] Vol. 30. No. 6. pp. 245-50. 1945.

** In discussion. Some of the conceptions which are expressed by the author were formulated earlier by V. L. Komarov in "Meridional zoning of organisms." 1920. See V. L. Komarov Selected writings. Vol. 1. 1945, p. 64.—Editor.

2. In the colder countries of the north and south, species diversity of the vegetation is significantly less than in tropical countries. This completely coincides with analogous data of the general geography of the higher plant species of the world.

3. From this apparently it is possible to draw the conclusion that the process of species formation proceeds most intensively in the tropics. However, this obviously is in conflict with the fact that in the tropics are concentrated the most ancient tribes of the grass family.

In the series *Festuciformes*, which includes tribes of later origin, the species are young and almost completely adapted to the temperate zone.

If study is undertaken regarding which genus of the grass family is the most rich in species in one or other region we actually find clear confirmation that species formation in the tropics, or in other places of the earth far from regions of energetic geological activity, is much slower than in zones of present-day geosynclines or in other regions of powerful geological action. Thus studying from this point of view the geography of those grass tribes in which the areas of some genera comprise tropical America, Africa or other regions of geological inactivity, and areas of others are found in zones of present geosynclines, we obtain the following data (Table 1) :

Table 1.—The Number of Genera and Species of Individual Tribes of the Grass Family in relation to Geographical Distribution

No. of tribe according to Roževic's summary	No. of genera distributed		No. of species		Average number of species in a genus	
	in the zone of geosynclines	outside the zone of geosynclines	in the zone of geosynclines	outside the zone of geosynclines	in the zone of geosynclines	outside the zone of geosynclines
II	28	18	565	38	21.0	2.1
VI	8	7	79	16	9.9	2.3
XVIII	11	17	295	62	26.8	3.8
XX	19	26	155	105	8.2	4.2
XXI	9	10	348	21	38.6	2.1
XXII	9	48	1045	214	116.3	4.5
XXV	3	2	95	2	31.7	1.0
XXVI	7	13	24	29	3.4	2.4
XXVII	33	45	589	149	17.9	3.3
Total	127	186	3195	636	25.2	3.4

II=Bambuseae ; VI=Oryzeae ; XVIII=Eragrosteae ; XX=Chlorideae ; XXI=Sporoboleae ; XXII=Paniceae ; XXV=Arundinelleae ; XXVI=Zoysieae ; XXVII=Andropogoneae.

1. The zones of geosynclines usually cover regions of distribution not of all genera of one and the same tribe of the grass family. As a rule in this zone there occur less genera than outside it. This is quite clear as a result of the fact that present zones of geosynclines cover only an insignificant part of the earth's surface.

2. The general number of plant species of one and the same tribe is considerably greater in the genera which occur in a geosynclinal zone than in genera of which the regions of distribution lie outside the geosynclines.

3. As a result of this the genera distributed in zones of present geosynclines on an average are more rich in species than are genera which do not occur here.

If comparison is made with genera of the legume family, putting into one group those genera of which the region of distribution is included in present geosynclines and zones of intensive geological activity, and the remainder in the other group, we obtain table 2 (7).

Of the total number of genera in regions which include the present geosynclines, the genera of the grasses and clovers constitute 40.5 per cent of each. On an average each genus which occurs in the zone of intensive seismic and tectonic activity com-

TABLE 2.—NUMBER OF GENERA AND SPECIES OF FAMILIES OF LEGUMES, WHICH OCCUR IN, OR OUTSIDE, REGIONS OF GEOSYNCLINES

Name of group	Occurring in geosynclines			Outside the zones of geosynclines		
	Genera	species	Average	Genera	species	Average
I Mimosoideae	11	1206	109	19	132	6.9
II Caesalpinioideae	21	719	33.9	70	290	4.1
III Papilionatae	140	5105	35.6	164	1161	7.1
TOTAL	172	7030	40.8	253	1583	6.2

prises 25 species of grasses and 41 of legumes. Genera which are not met with here are on an average much poorer in species ; the number of species of grasses being on an average only 0.13 and those of the legumes 0.15 of the number of species in genera occurring in the geologically active zones.

This has been confirmed in observations on other families, whatever the total area of their distribution. If, for example, the families distributed in the tropics are considered (palms, myrtles, Bromeliaceae), or those only in cold or temperate regions (willows), or chiefly in northern temperate countries (Boraginaceae) we obtain the following data.

TABLE 3.—NUMBER OF GENERA AND SPECIES OF SOME FAMILIES WHICH ARE DISTRIBUTED IN, OR OUTSIDE, GEOSYNCLINAL REGIONS

Family	Zone of intensive geological activity			Zone of relative quiescence		
	Genera	species	Average No. in genus	Genera	species	Average No. in genus
Palmae	86	990	11.5	44	127	3.0
Myrtaceae	58	2516	43.1	10	46	4.6
Bromeliaceae	19	950	18.4	19	119	6.3
Boraginaceae	65	1199	28.1	17	38	2.2
Salicaceae	2	178	89.0	—	—	—

Even among the most diverse families of higher plants, on an average those genera, of which the area of distribution includes the zones of intensive geological activity, are always more rich in species compared with the other genera. This is observable

despite the fact that the number of endemic genera, represented by only one species, is often fairly large in the case of precisely those genera which are distributed in zones of geosynclines, earthquakes and similar phenomena. Even in those groups of floral regions which are adopted in these composite monographs, the peculiar character of the flora in zones of intensive geological activity stands out clearly. Undoubtedly it is still sharper in comparison with the flora of regions which accurately coincide with intense geological activity and with zones of quiescent earth conditions. It must be expected that in this case even extensive regions will have significantly fewer species than those with less extensive zones " of the centres of origin of species."

All this confirms that the genera containing the greatest number of species are concentrated in zones of intensive activity of the earth's crust, that geological and organic changes in the earth are most closely connected both in space and time, and that the present centres of intensive geological activity, and in particular young geosynclines, are those basic areas of the earth where the process of species formation is especially intensive.

Besides the abundance of species of one and the same genus, a good indication of the frequency of occurrence of new species in one or other area is the number of endemic species. Accepting the theory of preponderating species formation in regions of intensive geological activity, in the territory of the U.S.S.R. we rightly expect the greatest variety of fodder grasses to be observed in regions near, or within, geosynclines.

Among the floristic regions of U.S.S.R., exceptional species formation of flora is therefore expected in the Pamir-Altai regions, the Tjanj-San and Dzungaro-Tarbagat regions which are found in zones of intensive seismic activity, and also in Kamchatka which is in the zone of intensive volcanic activity. An increased number of species should be found near the southern end of Lake Baikal (earthquake zone at the junction of the regions of Angaro-Sajan and Dauria) and in the low-lying lands of the Amur (earthquake zones, Udskii region).

If we compare the number of species in the grass family which are found in the various regions and groups of them with the geographical division in the Flora of the U.S.S.R., this is well confirmed (see table 4).

As regards the total number of species, the average number of species in a genus, and the number of endemic species, the regions of Pamiro-Altai, Transcaucasia, Tjanj-San, Kamchatka, and in a lesser degree, the Crimea, Altai, Angaro-Sajan, the Ussuri region and the highlands of Turkmenia, are indeed outstanding.

If the " centres of origin " of cultivated plants, established by the researches of N. I. Vavilov and his school, are compared with regions of intensive geological activity, we obtain further indication of the coincidence of regions of intensive species formation in plants with zones of active geological activity, and with contemporary geosynclines. The coincidence is so complete that it is astonishing how up to now neither geologists, nor botanists have demonstrated this connexion (see map).

The theoretical and practical significance of this coincidence is great. In the first place we are forced to conclude that it is in regions of intensive geological activity that we should look for the greatest variety of systematic forms, not only of plants cultivated long ago, but plant species in general, and that the creation of new species arises under the influence of those factors which are active at the present time in these regions.

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ENGLAND

RELATION OF EARTH MOVEMENTS TO FORMATION OF PLANT SPECIES

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ENGLAND.

Table 4.—Average Number of Species and Genera in Families of Grasses, and Number of Species which occur only in one region

Name of region	Number of species	
	Average in one genus	Endemism
Crimea	2.1	13
West Transcaucasia	2.8	26
East Transcaucasia	3.3	13
South Transcaucasia	2.9	37
Remaining areas of European parts of U.S.S.R.	1.6—2.8	0—7
Altaĭ	3.2	12
Angara and Sajan	3.2	15
Ussuri	2.1	13
Highlands of Turkmenia	2.2	12
Pamir-Altaĭ	3.7	63
Tjanj Šan	3.4	20
Remaining areas of Asiatic parts of U.S.S.R.	1.9—3.4	0—8

Since all centres of origin of cultivated plants occur in zones of present geosynclines, it is possible to regard the species diversity concentrated here chiefly as the result of continuing intensive species formation arising from geological changes in the earth's crust and not as a result of their primary introduction into cultivation in these regions. There is much evidence against this last alternative :

1. The great systematic diversity of species of cultivated plants concentrated here, must not be regarded, even if only in the main and not wholly, as a result of man's selective action because we see how among wild plants in some families, the greatest species diversity is concentrated here.

2. Many species have been brought under cultivation outside the zones of geosynclines, but they have their greatest diversity concentrated not in the place of their first introduction, but in other places coinciding with geosynclines.

3. Even if it is accepted that the first homes of agriculture on the earth arose in mountainous regions, natural strongholds easily mastered by small groups of people [2, 3], it is quite impossible to understand why all these centres of cultivation occur in mountains of present geosynclines. The natural strongholds are many and are also among mountains of older origin : Caledonian, Variscan or Hercynian and even Huron mountain-formation phases. Yet in these mountain regions there are no centres of origin of agriculture, and nobody looks for them there, where there are no centres of species formation. These discrepancies are removed if the hypothesis postulated by us is accepted, namely, that changes of the organic world arise at the same time and in the same area in which geological changes of the globe take place, and that the intensity of the variability of the organic world is directly connected with the intensity of change in the earth's crust. Support of this is not difficult to find in historical geology and palaeontology.

From all the above it is clear that geological changes in the globe and variability of organic forms on the earth are closely connected between themselves, and consequently factors which are active in the earth at the present time are the causes of these changes. The following should be noted :

1. Zones of the earth with the greatest intensity of geological action coincide with zones of the greatest variability of plants.

2. An outburst of geological activity arises simultaneously with an outbreak of species variability in plants and animals. In aquatic animals changes are more intensive, apparently, in the period of formation of geosynclines, and in land plants during the period of upheaval, contraction, and during mountain formation (folding), when geoanticlines are created.

3. Present geosynclines are the present centres of species diversity, and the primary centres of species formation. Old geosynclines were likewise centres of species formation of palaeontological fossil organisms.

4. Consequently the conclusion is drawn that during the life of this planet there are short periods of revolutionary outbursts in species formation, and longer periods of quiet, evolutionary development.

5. From time to time in comparatively narrow localized centres there occur outbreaks of intensive species formation, the creation of new forms of life—powerful waves of evolution arise which spread out from this centre. Under the influence of such geological waves over the immense expanse of the globe in a comparatively short period there occurs an intensive change of old forms of life with new.

6. " There scarcely exists a more striking palaeontological discovery than the fact that forms of life change on the globe almost simultaneously " [4, page 546]. Regarding the inhabitants of dry land and fresh waters, this expression is less clear, but quite understandable if the peculiarities of their distribution are taken into consideration. This striking fact is a natural consequence of the irregularity of evolution, and of the synchronization of a specially intensive species formation with the time and place of vigorous geological activity. New forms arising in such centres after propagation break forth in a mass into other areas, causing upheaval among the existing populations. Observations on plain-land forms lead to the view of immutability of species, and give rise to the theory of cataclysm in palaeontology.

An especially acute change of form is observed in those cases, when remote, isolated regions which lie outside the action of geosynclines become accessible to colonization with new forms which demonstrate their vitality by having survived and multiplied themselves in wide territories which adjoin the geosynclines.

7. If the species or genus as regards its geographical distribution is far removed from new geosynclines which are active, then its variation is accomplished at a much more slow rate compared with that of other species and genera, in the areas of which geological factors are intensively active. Consequently a species or genus, isolated from the influence of geosynclines, will carry traits of a more ancient type, and, living in " tranquility," experiencing less intensive and less manifold struggle with existence, may long be preserved as a relict in regions isolated from the action of waves of life which emanate from geosynclines. Such waves have only to break through into these quiet creeks and backwaters and many species and genera disappear with cataclysmic and unusual rapidity " from unknown causes".

8. The great diversity of genera in significant measure occurs as a result of: (a) transmigration of the organic world from the southern and northern hemispheres as the glaciers spread; (b) persistence of the outward conditions of life in the tropics during a lengthy succession of geological periods, and (c) a diminution in the struggle for existence between the species and their forms which arise from changes in external conditions of life.

9. For any period of the earth's life, regions of the most intensive species formation of any plant genus occur in those places where the area of the genus crosses the zones of more intensive geological activity of the earth's crust of a given period. The intensity of evolution is manifested in a great number of species, varieties and other young ecological forms belonging to a given genus. Endemic species, varieties, and still younger ecological forms are frequently met with here, while in regions of quiescent geological activity and in places suitable for life, even though a great diversity of vegetation will be in evidence, endemism of the older groups of ecological forms—genera, tribes, sub-families and others which are characteristic of the older stages of the evolutionary process—will be met with more frequently.

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FORAGE PRODUCTION IN SWITZERLAND: ITS CONDITION BEFORE THE WAR, CHANGES DURING THE WAR, AND POSITION IN THE POST-WAR AGRARIAN PROGRAMME*

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INTRODUCTION

In an article on the changes that have taken place in forage crop production in Switzerland in the last 10 years and the future significance of this branch of agricultural production, a few general observations must first be made.

Switzerland, contrary to the opinion frequently held abroad, is not an agrarian but an industrial country. Of the total population of 4.3 million, not more than one-fifth is employed in agriculture. Nearly four-fifths are employed in other fields of work, especially in industry, in trade and commerce, in the tourist industry, etc. It is well known that the nature and strength of different types of employment are of decisive influence on the agrarian policy of a country. But for Switzerland it may be said that this policy, in spite of the one-sided nature of the population's employment, stands on a good foundation, and this is principally because the Swiss farmers have co-operative organizations in all parts of the country and compose, in the agrarian political sense, a unity.

Small and medium-sized holdings predominate. Not less than 82 per cent of the total of 240,000 farms are of a size less than 10 hectares and only 1.1 per cent of all the farms exceed 30 hectares. The average size of a farm is 5.7 hectares.

Geographically, Switzerland belongs to the alpine countries. Climatic and pedological conditions are very varied and are expressed especially in the different farming zones, which find their lowest altitude at 200 metres, the highest at over 2,000 metres above sea level. Annual rainfall ranges from 600 mm. in the driest localities (Valais) to over 2,000 mm. in the most humid places (Säntis, St. Gotthard). The mean annual temperature is subject to similar variations, so that in one case there is a growing period of approximately 7 months, in another of hardly 3 months, while during the rest of the year cold and snow prevail.

The topography is hilly and mountainous. There are no extensive plains. Of a total area of 4,129,493 hectares, 931,177 hectares (22.5 per cent) are unproductive. Of the productive area of 3,198,316 hectares, 1,024,425 hectares are occupied by forest and 2,173,891 hectares by agriculture and alpine farming. The last-named section may be divided into cultivated land in the narrower sense of the term, having an area of 1,168,374 hectares, and into alpine pastures with a total area of 1,005,517 hectares. In regard to yield, there is a ratio of approximately 15 : 1 between the cultivated land in the narrower sense of the term and the alpine pastures.

The centre of gravity of agricultural production rests on animal husbandry and forage production.

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* Translated from German by G. M. Roseveare.

Condition of forage production before the war

In order to describe the condition of forage production in Switzerland before the war, some statistical information is first necessary. The cultivated areas in the narrower sense, referred to in the introduction, were composed as follows in 1939 :

	Hectares	Per cent
Open arable land	209,301	17.9
Forage production	919,055	78.7
Vineyards	10,543	0.9
Rough grass for litter	26,167	2.2
Special crops	3,308	0.3
Total	1,168,374	100.0

Some statistical information is also available on the structure of the forage production of that time. The total forage crop area was composed as follows :—

	Hectares	Per cent
Well-manured natural meadows (fat meadows)	671,739	73.1
Poor natural meadows (poor meadows and alpine foothills)	80,603	8.8
Pastures in the central country (except alpine pastures)	27,475	3.0
Herbage leys	139,238	15.1
Total	919,055	100.0

These few figures show that grassland and forage production occupied a predominant position in the agriculture of the pre-war period as far as area was concerned. Its importance becomes still greater, however, when the alpine area, which is almost exclusively used for the production of fodder, is also taken into account. The growing of natural forage crops accounts for by far the greatest part or 85 per cent of the total forage area. Only 15.1 per cent is occupied by artificial herbage leys, but the fact that the growing of sown forage crops comprises almost 70 per cent of the open arable land is nevertheless striking. In this proportion there is expressed first and foremost the endeavour of the farmers of that time to keep as much land as possible under the plough, and to use a very considerable part of it as herbage leys within the crop rotation.

From the statistics of animal husbandry in Switzerland for the year 1940, it can be seen that the number of cattle units, exclusive of pigs and other small animals such as poultry, rabbits, etc., amounted to 1,637,000. As the alpine pastures can feed annually approximately 100,000 cattle units (about 400,000 units per 90 days), this gives for the total forage crop area of the cultivated land in the narrower sense, 919,055 hectares, 1,537,000 cattle units or 0.595 hectares per cattle unit. When one urther considers that, at the same time, only approximately 5 per cent of the annual orage consumption and hardly 0.5 per cent of the rough fodder is imported from

abroad, then the figure of approximately 0.6 hectares fodder area per cattle unit may be regarded as a measure of the intensity of the forage production.

The economic position of agriculture in Switzerland was unsatisfactory in the pre-war period. There was an excess of animal products, especially of milk and dairy products. To modify the marketing crisis and prevent a severe fall in price, milk control, that is to say, the restriction of milk deliveries within a prescribed maximum based on area, had to be exercised for a long time in addition to the granting of government subsidies. If the maximum delivery was exceeded, the excess deliveries were subject to considerable reductions in price.

This crisis was not without effect on forage production. An important means of widening the market was seen to lie in the improvement of the quality of the milk and dairy products. There is no doubt that the type of fodder, feeding, the condition of the animals, etc. are important factors affecting the quality of the milk. Problems of modern grassland management, of manurial treatment and weed control, therefore, were those which especially interested and occupied the research worker.

It was at this time that the Association for the Promotion of Forage Production was founded, an association which, as its name implies, has as its main object the encouragement of forage production. Its object is described as follows in the Statutes. " The aim of this Association is in the first place to bring about a close co-operation between all societies, institutes, farmers, and research workers interested in the production of fodder of first-rate quality, and to promote a better understanding between farming practice and scientific research." The Association endeavours to attain this through the following measures.

(a) Addresses by experts in the fields of plant husbandry, animal husbandry and dairying on especially important questions of forage production.

(b) The initiation and conduct of investigations and experiments in grassland and forage crop improvement at agricultural experiment stations and agricultural colleges, help being given in experimental technique and the suitable distribution of work.

(c) Encouragement in carrying out experiments and keeping of records on ordinary farms, if necessary under the personal supervision of the farmer.

(d) Propaganda through addresses and press communications on questions already studied and elucidated ; publication of practical advice and summarized information.

(e) The collection of observations by means of questionnaires and press enquiries.

To-day, at the beginning of its 13th year's work, the Association has approximately 1,600 members. Its main centre of activity is located at the Federal Agricultural Research Station, Zürich-Oerlikon ; a branch station at the Federal Station for Seed Trials and Control, Mt. Calme, Lausanne, is more especially at the service of members from the French-speaking part of Switzerland. Of the Association's work up to the present there may be mentioned the publication of twenty-nine communications and eight leaflets, twelve separates containing the results of experimental and research work hitherto carried out, and two books. Numerous courses and conferences have been held for educational and advisory work. A special opportunity of justifying its existence was given to the Association during the war years, when large areas devoted to grassland and forage crops had to be sacrificed to the increased production campaign and it was necessary to mobilize the various reserves still available in the crop production system of Switzerland.

Forage production during the war

The international political situation before the war early induced increased watchfulness on the part of the Federal Authorities. The outbreak of war thus found Switzerland well prepared to protect her neutrality not only in the military sense, but also economically. The war-time organization of the country's economy was to a great extent planned ; the officials in charge of the most important posts were nominated and had been entrusted with their tasks.

It was clear, taking into consideration the conditions of production to date, that to ensure the country's supply of foodstuffs special difficulties would have to be overcome. Agricultural production in any case would have to be considerably rearranged and directed more especially to the production of foodstuffs of plant origin. Rearrangement of this nature was to be founded on a survey of agricultural production which, on the proposal of Dr. F. T. Wahlen, was begun before the war and was for the most part completed during the first years of the war. The survey furnished the basis on which the increased cultivation quotas were distributed. This method proved extraordinarily successful in that it prevented demands for increased production being made in places where the necessary conditions were non-existent. The success of the increased production campaign and therewith the ensuring of supplies of food are to a great extent attributable to this wise planning.

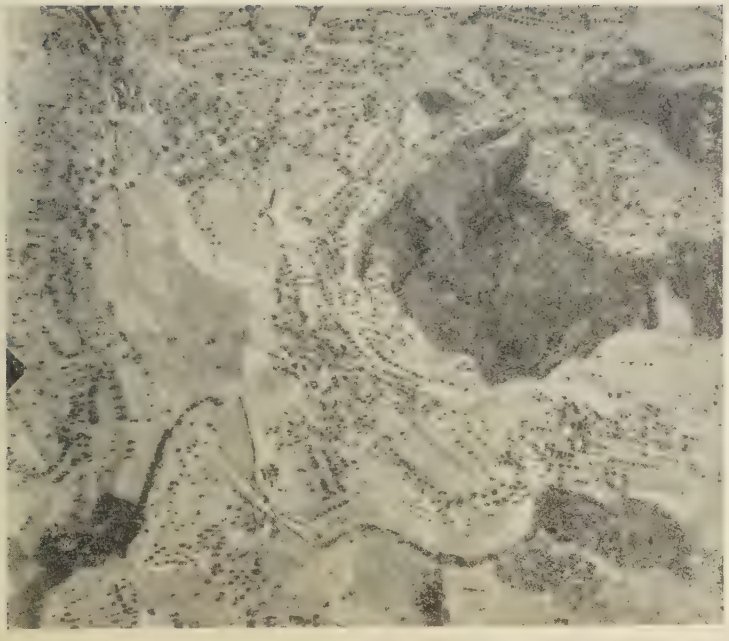
The transformation of agricultural production took place in seven stages. The areas planned as obligatory and the areas which the country was actually successful in cultivating are seen in the following table.

Year	Obligatory areas Hectares	Areas actually cultivated Hectares
1940	208,812	217,222
1941	276,290	270,541
1942	309,600	309,010
1943	368,700	352,226
1944	362,464	365,856
1945*	362,464	367,050

* Obligatory areas including an increased production of 40,000 hectares of catch crops for forage. The increased production area of 20,000 hectares was to be compensated by growing catch crops on twice that area.

If from the area actually cultivated the area occupied by smallholders is subtracted and the corresponding figures for the forage crop area of 1939 are compared, then the areas retained for forage crop production in the war-time years become reduced as follows :

Year	Forage crop areas Hectares	Relative figures
1939	919,055	100
1940	915,858	99.5
1941	864,845	94
1942	828,937	90
1943	787,235	85.5
1944	773,985	84
1945	772,063	84



1a

1b

Figs. 1a and 1b. The extension of field crop cultivation in Switzerland during the war, in a district where there had been none previously. Photograph : Federal Topography Service.

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Fig. 2 a

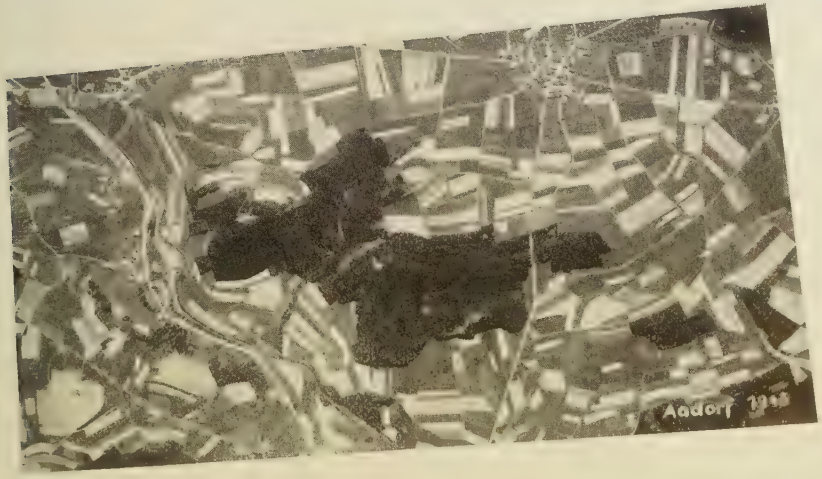

Fig. 2 b

Figs. 2a and 2b. The extension of field crop cultivation in Switzerland during the war, in a district where there was only a limited amount previously. Photograph: Federal Topography Service.

Fig. 5

Fig. 6

Fig. 5. The natural plant stand of a poor hayfield, only occasionally manured and always used for mowing (two cuts annually for hay). Photograph : A. Kauter.

Fig. 6. Vetch-pea mixture with maize and rape as support crops, grown after winter barley. Photograph : A. Kauter.

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The grassland and forage crop areas were thus reduced in the course of the war by 16 per cent. At the same time the number of cattle units was reduced to 1,472,000 or by 10 per cent. The reduction in the number of cattle entailed, however, a considerable loss in manure which was serious, more especially in regard to phosphoric acid, available in the form of commercial fertilizers in very small quantities only. The reduction in the yield of fodder thus caused corresponds to an amount which could cover the requirements of approximately 25,000 cattle units. To the reduction of area there must therefore be added a quantitative reduction also, amounting to not quite 2 per cent. Compared with an 18 per cent reduced yield of fodder due to reduction of the area and lack of manure, there would then be a reduction of only 10 per cent in cattle units.

In this ratio there are reflected Switzerland's achievements during the war in improving the basis of home-produced fodder. Throughout the whole of the increased production campaign the important principle was, by means of opening up new sources of fodder, to avoid reducing the amount of stock to the same extent as the grassland and forage crop areas. The increased production constituted therefore the means of introducing forage crop production on a broader basis on the ordinary farms and of utilizing every possibility of increased fodder production. This covered in particular :

(*a*) The introduction of artificial or temporary leys where they had been hitherto lacking.

(*b*) A wide utilization of fallow arable land for the production of fodder through the growing of catch crops (fodder crop production on arable land).

(*c*) An increased utilization of arable crop residues for animal feeding (beet leaves, fodder potatoes, straw, etc.).

(*d*) A reduction of conservation losses (the drying of hay on frames, ensilage, artificial drying).

At the beginning of the war there was no field crop cultivation at all in the regions of high rainfall. There were no ploughs, no machines, no implements, and in addition the knowledge and experience necessary for crop growing were entirely lacking. Endeavours here were especially directed to convincing the individual farmers of the advantages of a systematic crop rotation, in which the artificial herbage ley should take an important place. But it nevertheless proved necessary in the sixth stage of the increased production campaign (autumn 1943, spring 1944) to make it obligatory for at least 10 per cent of the arable land to be laid out in temporary herbage leys in the new arable regions.

In the seventh stage of the increased production campaign (autumn 1944, spring 1945), which required a further extension of open arable land totalling 20,000 hectares, it became possible to obtain increased areas through cultivating double the area of catch crops for feeding stuffs. Herein a promotion of forage production on arable land was envisaged and was to a large extent achieved, as is shown by statistical returns. Especially valuable in this respect were the subsidies granted by the Confederation and by the Cantons since 1943 for the construction of green fodder silos, amounting to at least 10 francs per cubic metre silage capacity and about 20 per cent of the costs of construction. The total silage capacity for the conservation of green fodder in Switzerland amounted at the end of 1945 to approximately 550,000 cub. m.

or somewhat more than six times that of 1939. In this connexion, it must be remembered that of the total number of 3,876 Co-operative Dairy Societies, 1,191, that is almost one-third, are in a zone where ensilage is prohibited and farmers have to refrain from the making and feeding of silage because of the industrial use of milk for cheese. A partial substitute was obtained in these regions by the installation of grass-drying plants. By the end of 1945 the electric driers available reached an annual production of approximately, 1,000 railway trucks each with a capacity of 10 tons dried grass.

It was interesting to trace the effects of the rearranged production and transformation of farm organization on the structural composition of animal feeding. We endeavoured to determine this through an enquiry circulated among the members of the Association for the Promotion of Forage Production in the year 1945. The open arable land on an average of 261 farms amounted to 40 per cent of the total farm areas excepting woods and special cultures (the mean for the whole of Switzerland was 30 per cent). The following areas participated in producing the total yield of fodder :

	Per cent
Natural meadows	55.6
Herbage leys	22.6
Stubble cut of new-sown herbage leys	3.4
Spring cut of herbage leys before ploughing and planting	2.2
Catch crops (on arable land)	6.6
Silo maize	4.2
Beet leaves, straw, chaff, other residues	5.4
Total	100.0

On the basis of the same enquiry, we could see that, with the increase in the open arable land to the extent of approximately 5 per cent of the farm area, the forage crop area necessary for the feeding of one cattle unit was reduced to 2 to 3 ares. With an increasing proportion of open arable land more possibilities of artificial leys and catch crop production exist, so that the increased yields thereby produced have in consequence a smaller absolute area of forage crops per cattle unit. The farms covered by the enquiry are situated herein as follows :—

Open arable land in percentage of the area of the farm. Per cent	Number of farms	Absolute forage crop area per cattle unit. Hectares
Less than 25	23	0.57
25-30	20	0.59
30-35	24	0.50
35-40	34	0.45
40-45	39	0.43
45-50	42	0.44
50-55	40	0.39
55-60	24	0.34
Over 60	15	0.31
	261	0.46

These facts may help to explain the results obtained for the whole of Switzerland, according to which a reduction of the forage crop area of 16 per cent is offset by a reduction in the amount of stock of only 10 per cent.

It is clear that during the war the centre of gravity of forage crop research rested almost exclusively on problems conditioned by the times. A large proportion of research was devoted to forage production on arable land, where questions of whether or not it was possible to grow given crops had to be studied more particularly. Further questions were concerned with the production of seed of herbage and forage plants, special problems of ley cultivation (seeding rate, mixtures, etc.), testing of seed from different sources, etc. Advisory and instructional work based on previous experiments and on experience also formed an important part of the research worker's activities.

Position of Forage Production after the War

The post-war programme for agriculture in Switzerland follows in the main two objectives. In the first place it is desirable as far as possible to prevent a repetition of the conditions prevalent in the pre-war years, and secondly, it is necessary to ensure that the experience gained during the war shall be retained and further developed.

Both objectives may be attained in general through keeping intact a minimum of open arable land estimated at approximately 300,000 hectares. This method, however, requires a large amount of help on the part of the State in regard to production and price policy, the main problem being the creation of a certain degree of parity between the prices of arable products and those of animal products, so that the weaker side in regard to marketing and price shall be favoured. The necessary legal bases for this are contained in the so-called Articles of Economy which have been discussed and passed by the Federal Councils (National- und Ständerat) and within the near future will be voted on by the Swiss people.

The reduction of the present open arable area of approximately 365,000 hectares to 300,000 hectares is planned so that even in the regions which are less favoured climatically a small amount of arable cultivation shall be retained, designed primarily for the growing of subsistence crops. Naturally the reduction of the area will be gradual. Regions especially suitable for arable cultivation will give up only a little, while in those parts of the country where the rainfall is heavy a greater reduction will take place.

The present planning for post-war agriculture implies for forage production the retention of the position reached during the war. The tendency to keep the hitherto open arable land as far as possible still under the plough, and to transform that part which is to be reduced into long-duration temporary leys, must unquestionably be favoured. The other method, the reduction of the open arable area through the creation of permanent grassland, should be taken in exceptional cases only. A consequence of the first method is certainly that the duration of the temporary leys, which to-day, without counting the seeding year, is on an average 2 years, will be prolonged by 1 or 2 years. But in general, remembering that the cultivation of temporary leys is only possible in connexion with arable cultivation, it must be expected to increase, thanks to the higher yields obtained.

In the post-war period the questions of technique, labour and profitability will have a decisive effect on catch crops on arable land. But presumably they will decrease somewhat in area and to an increased degree occur as a gap-filler when for some reason the other herbage and forage crops have been inadequate. In judging profitability one often forgets to take into consideration the indirect effects of the growing of forage crops on arable land (maintenance of soil fertility, suppression of weeds, etc.).

Increasing the size of the forage areas will also affect the production of the so-called natural fodder (herbage and hay) which takes by far the leading position as regards area. In particular there are again increased possibilities of pasture areas which during the time of the maximum crop production were often much restricted, but which are of great importance for the maintenance of good plant stands in the natural meadows.

Great attention is to be paid in future to the reduction of losses of nutrients in fodder conservation. Hay-drying frames of the greatest variety of types are already common on the farms. In the same way, as experience up to the present has shown beyond any doubt, ensilage will become more customary wherever milk goes direct to the consumer or is used for butter-making. Whether the same will be the case with artificial drying depends mainly upon whether it is possible to put it on a better economic basis by increasing the efficiency of the driers.

The most important questions and problems which will now have to be studied by the grassland research worker are concerned with the following points :

1. Improving the foundations of seeds mixtures through intensive study of competition and compatibility in the different species.
2. Studies of seeding rate.
3. Determination of suitable short-duration mixtures for altitudes of over 1,000 metres.
4. Studies of methods of determining pasture yield.
5. Improving the indigenous perennial red clover.
6. Various problems concerning alpine pastures.

Summary

Switzerland, as a neutral State during the war, had to a large extent to rely upon home-produced food supplies. Connexions with foreign countries, and in particular relations with foreign scientific workers, were almost entirely cut off. We rejoice, therefore, to take up again the threads of intercommunication that lead to progress. This also is the principal object of the present article, which presents first a condensed review of agriculture in Switzerland before the war, with special reference to forage crop production, and then describes the transformation which took place during the war under the leadership of Dr. F. T. Wahlen in order to ensure food supplies for the country. Here also those points which are concerned with forage production receive special attention. Finally, there is presented a short consideration of post-war conditions in general and those of forage production in particular, with a very brief note on the problems which at present await solution.

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A Scottish Method of Grassland Improvement

The work in progress at Corstorphine, Edinburgh, is outlined by Dr. J. W. Gregor in the Report (abridged) by the Directors and the Report to the Annual General Meeting of the Scottish Society for Research in Plant Breeding on July 18, 1946. The results obtained so far at Dalmahoy and Whelpside, near Balerno, and in the Dundonnell area in Wester Ross are summarized as follows.

Broadly speaking, the investigations aim at finding a method of grassland farming whereby specialized cultivated pastures could be employed as the nutritional complements of adjacent rough grazings with the object of utilizing to the full the potentialities of both. The work is being carried out under two heads: (1) the breeding of specialized races and the search for suitable ecotypes of grassland plants, and (2) the assessment of their value under a system of complementary grassland utilization. These two aspects are so intimately related that they are being treated as parts of the same problem—a problem which is being studied both at Craigs House and at field centres in "marginal" districts.

Dalmahoy Centre. Briefly, the results to date suggest that when vegetations of widely contrasting type—e.g., highly cultivated and natural—are grazed as complementary pairs the utilization of the paired vegetations is more efficient than when either is grazed separately; and secondly, the cultivated member of the pair can, in the circumstances, be relatively small and botanically simple. So far only the productive capacities and competitive relationships of different maturity races of perennial ryegrass have been examined, but a start has now been made to deal with the chemical aspects of the problem.

The trial area has been grazed as the complement of a much larger area of rough pasture. The grazing season extended from April to October, both months inclusive, but the actual grazing time was divided into periods of 3 weeks, each period being separated by rest intervals of a week. At the start of each rest period the herbage of the sample areas was again cut, and this time weighed. Thus the figures obtained relate to production and not to the amount of herbage consumed by the animals.

The data showed that in respect of the total seasonal production the difference between the highest yielding races of the contrasting maturity types is negligible. On the other hand, there is positive evidence that the different maturity types when grown in pure culture can be used to spread production more evenly over the grazing season, though the spread is largely negatived when distinctive types compete with each other in a mixture. In fact, by the third year under the prevailing system of management, mixtures comprising extreme maturity types exhibited production cycles not very different from those of their early constituents growing in pure culture. On examination of the racial composition of one of these mixtures which in the first year contained 56 per cent early varieties and 44 per cent late, it was found that by the third year the percentage of early varieties had risen to 74. However, judging by the rapid change towards a homogeneous ryegrass/wild white clover sward of a control species mixture, it would seem that inter-racial competition among ryegrass types is somewhat less intense than that between ryegrass and cocksfoot.

There is no doubt that if specialized systems of grass farming are to find a place

in upland agriculture, the relative values in terms of production spread, of species and racial mixtures and of races in pure culture, deserve to be critically examined.

Under a system of complementary grazing the cultivated complement will inevitably lie adjacent to an inferior grazing, and since many a rough grazing, Dalmahoy not excepted, is a breeding ground of the crane-fly (*Tipula paludosa*), the question of leather-jacket control becomes a very important one. Leather-jacket damage to the cultivated area at Dalmahoy is almost entirely confined to patches on the early ryegrass plots, where the grazing had been least efficient. The matter was referred to Dr Cameron of the Department of Entomology, Edinburgh University, and as a result the area has been examined by his assistant, Mr. West, who records the following leather-jacket counts: *cultivated area*—bare patches 2,000,000 per acre, remainder 700,000; *adjoining rough pasture*—1,000,000 per acre.

Whelpside Centre. In May, 1945, races of perennial ryegrass, cocksfoot, and timothy were sown as pure cultures and as mixtures under various grazing nurse-crops. Eight hundred pasture samples were analysed botanically in April of this year. The results show no difference in pasture density between plots seeded under cereals and those which lacked a nurse-crop. However, the effect of a series of Brassica nurse-crops was to reduce the density by 31 per cent. While the effect of the Brassicas (turnip, rape, marrow-stem kale, and thousand-headed kale seeded respectively at 6, 7, 8 and 8 lb. per acre) was to lower the establishment value and give a relatively open and tufted type of pasture, these nurse-crops nevertheless allowed cocksfoot to compete successfully with perennial ryegrass. For instance, in the Brassica series perennial ryegrass contributed 57 per cent to the total population originating from equal quantities of viable seeds of the two species, whereas in the cereal and no nurse-crop series perennial ryegrass contributed 81 per cent.

Italian ryegrass employed as a nurse-crop and sown at the rate of 10 lb. per acre also had a markedly adverse effect on cocksfoot establishment, though it had little or no effect on the establishment of the early races of perennial ryegrass. With heavy autumn and light winter grazing, however, the establishment value of cocksfoot was only 16 per cent less than when under a cereal nurse-crop, but when lightly grazed in autumn and not at all in winter, this percentage rose to 62.

Under the conditions of the present trial the cereals were ready to graze 7 weeks after sowing, or 17 days sooner than the Brassicas. Oats and barley gave equally early returns, but the latter made a relatively poor recovery after an initial grazing period. Winter rye, like Italian ryegrass, though less productive than either oats or barley during the first grazing period, added a greater amount of autumn herbage, while the Brassicas, though reaching their optimum grazing stage considerably later than the other nurse-crops, outyielded them all in bulk of produce. Nevertheless, for complementary pastures where quick establishment and a short interval between seeding and grazing are desired, and moreover where a floristically simple vegetation is no disadvantage, oats (cleaned seconds sown at the rate of 3 bushels per acre) are likely to meet average requirements.

Dundonnell Centre. While arrangements were being made for establishing the Dundonnell Home Farm Centre, a start was made on another farm in order to obtain advance information as to grassland conditions obtaining in the district. For this purpose Mr. A. S. MacLean kindly put a 1.5-acre grass field on the farm of Black Muir at the Society's disposal.

This field is part of the arable acreage, but from the point of view of cereal cultivation must be regarded as sub-marginal, for the yield of oats in 1935 did not exceed the 6 bushels sown. On May 3rd, 1945, it was reseeded with a grazing nurse-crop of Bell oats and winter rye, and a ryegrass strain of Cornish origin raised from seed collected by Mr. F. R. Horne, Director of the National Institute of Agricultural Botany.

The reseeded area was for part of the season used as the complement of moorland vegetation, and, during the remainder of the season, of a 5-acre field of poor grass. With the exception of a 2 weeks' rest in early October the area was grazed continuously from 21st June 1945 to 16th January 1946.

Mr. MacLean's records can be summarized as follows :—

Stocking

Cows	Calves	Stirks	Hoggs	Grazing days of approx. 3.5 hours each
2	2	—	—	13
5	5	2	—	103
—	—	—	30	93
				209

The effects of the complementary diet were reflected by an increase in the general quality of the animals concerned. Based on the performances of previous years the yields of the two cows which were milked rose by 20 per cent and the hogg weights by approximately 5-6 lb. per head, while the calves were very much superior. No increase in the normal stocking of the farm was required to ensure full utilization of the reseeded herbage, and it is probable that even if the area were to be doubled it would still be no more than sufficient to correct the marked signs of malnutrition occasioned by the poverty of the rough grazings.

At the Home Farm Centre, thanks to the active co-operation of the Farm Manager, Mr. MacLeod, the maturity-type trials of perennial ryegrass and cocksfoot were sown on 11th May, 1946. These particular trials cover an area of 8 acres. Other special purpose trials will be laid down in due course.

Agricultural Seed Production as a New Industry in Welsh Farming*

Until quite recently commercial seed production was almost an unknown enterprise in Welsh farming. It is true that in Welsh upland areas farmers knew that they could retain the same potato stocks on their holdings almost indefinitely without finding any indication that yields were impaired.

* Reprinted from *Rural Wales*, Vol. 1, No. 2. pp. 8-12. 1946.

It has also been known that local strains of cereal seeds, particularly barley, obtained from the coastal areas of North and South Wales gave excellent cropping results on inland farms for several years before any deterioration of yields became apparent. The lowlands of Montgomeryshire, the Vale of Clwyd and the Vale of Glamorgan have produced, on a small scale, local strains of red clover, which are fairly widely known. There have also been farmers who have occasionally "grown on" cereal varieties under contract for established seed houses.

The possibilities of developing seed potato production on Welsh upland areas became apparent as a result of the work of Dr. Whitehead of the School of Agriculture, Bangor, on virus diseases. His investigations were followed by demonstrations over a wide area, and the suitability of upland farms for the production of healthy seeds was established. Later, the work of the Welsh Plant Breeding Station, Aberystwyth, on cereals, grasses and clovers directed attention to the possibilities of the production of these classes of seeds in certain lowland and some highland areas. Thus, two Agricultural Departments of the University College of Wales have, by investigation and demonstration, added scientific reinforcement to a number of traditional practices, and opened up many new possibilities for commercial seed growing developments. The shortage of good seeds during the war years gave an added impetus to convert these possibilities into practical account.

The Technique of Seed Production: At the commencement little was known of the technique of seed production among Welsh farmers. Crops were grown in accordance with the normal practices of farmers for use as stock feed or for sale for human consumption. In the case of potatoes, the School of Agriculture at Bangor was able, through its Advisory Service, to demonstrate and establish improvements in growing technique, dressing and grading. In the case of cereals, grasses and clovers, the Welsh Plant Breeding Station, in a similar way, provided guidance on the technique of growing, inspection, certification, cleaning, dressing, etc. The dissemination of information was assisted by the staffs of War Agricultural Executive Committees.

Organization: In order to make the expansion of seed production possible, certain services were required which could not be provided by the various research and advisory bodies. These included crop inspection, certification, cleaning, dressing, grading, packing, transport and sales. Such functions required collective action by growers and steps were taken by the Welsh Agricultural Organisation Society, Ltd., to organize growers co-operatively. This work commenced in 1928 but did not attempt to do more than deal with seed potato growing until 1933, when an association of growers was formed to "grow on" Aberystwyth strains of cereals. This association was not registered until 1940.

From 1939 onwards, work on organization made rapid progress, and by the end of 1945, twelve co-operative seed growers' societies of various kinds had been registered. These, with an additional organization now in process of formation, cover the whole of Wales. The table summarizes the position as it stands. It will be seen that two societies deal with potatoes only, two societies deal with potatoes, cereals and grasses, and eight societies deal with cereals, grasses and clovers.

To co-ordinate the work of these growers' organizations, the Welsh Seed Growers' Federation was registered, and in 1944 an additional Society, Dyfed Seeds, Ltd., was formed and registered. This latter is concerned with cleaning, dressing and market-

ing the seeds of four grower societies. The marketing is done through twelve requirements societies, both the grower and requirements societies being members of the organization. This is, therefore, a federation of Societies, and it has no farmer members. Its services are confined to its members in the South Wales area.

In North and Mid-Wales, cleaning, dressing, grading and marketing services are provided to growers' societies by four old-established requirements societies, namely, the Eifionydd Farmers' Society, Pwllheli, The Wynnstay Farmers' Association, Ltd., Llansantffraid, Montgomeryshire, the Foel Agricultural Co-operative Society, Ltd., Anglesey, and the North Cardiganshire Farmers' Co-operative Society, Ltd., Aberystwyth.

Altogether there are at the present time :—

Twelve Seed Growers' Societies.

One Seed Cleaning and Marketing Society.

Four Requirements Societies providing cleaning and marketing services.

Twelve Requirements Societies providing marketing services only, without dressing or cleaning.

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The Future of Seed Growing in Wales

Finance : It will be realized when the membership and acreages of the growers' societies are examined that not one of them has been able to expand its operations on a scale large enough to enable it to meet the cost of maintaining a manager. Each society's income is derived from a levy on members of about 1.5 per cent on turnover. About 1 per cent of this is required to cover the direct service of the society to its members, and 0.5 per cent is paid to the Welsh Seed Growers' Federation to meet the expenses of the general service it was intended that it should provide. The whole of the available income of the individual societies is absorbed by inspection, secretarial and certification expenses, leaving no provision for management.

The income of the Welsh Seed Growers' Federation in 1945 was approximately £500. Of this amount £200 was required to meet the expenes of meetings, printing, stationery and secretarial work, leaving a balance of about £300 for the hitherto inadequately provided development work. This, it will be appreciated, is not sufficient to meet the expense of providing a competent field officer together with travelling and office expenses. This, however, could be done if the Welsh seed acreage could be doubled.

Development : At the recent Annual General Meeting of the Welsh Seed Growers' Federation, Ltd., the following matters were strongly emphasized :—

1. It has been established that seed potatoes of an exceptionally high standard of health can be produced on poor hill farms at elevations of 500 to 1000 feet.
2. The growing of improved local strains of cereals such as the oats, Ceirch Llwyd and Ceirch Du Bach, can be extended considerably on highland farms with poor soils.
3. The growing of local and other varieties of barley and other cereals can be developed in a number of Welsh coastal belts.
4. The growing of the new " S" strains of Aberystwyth cereals, grasses and clovers can be developed on lowland farms to a very considerable extent.

5. The necessary organization for the determination of standards of quality, inspection, certification, grading, cleaning, dressing and marketing has been established, but the acreage of seeds grown is entirely inadequate to provide for the efficient management of the numerous growers' organizations formed.
6. In order to promote and increase production the services of a competent field officer are urgently necessary. Such an officer would work in collaboration with the Technical Development Committees of the War Agricultural Executive Committees and the Advisory Service of the Ministry of Agriculture. His work would be to contact farmers in suitable areas for the purpose of bringing about an increase in the production of seeds as rapidly as possible.*
7. The production of high-quality certified seeds is of direct importance to farmers generally, and to farmers on poor highland farms the production of seed potatoes and suitable local strains of cereals has an important bearing on the future prosperity of such farms. Similarly, the production of other cereals, grass and clover seeds can be of the utmost importance to the maintenance of prosperity in lowland areas suitable for this type of production.
8. As a condition attached to the policy of guaranteed prices, the Government will demand efficient production. During the war years the cost of labour has increased considerably and more capital will be needed in the form of better buildings, machinery and equipment.

With these increased commitments for labour and capital, farmers cannot in the future afford to use inferior low-priced seeds. Such a practice, which has been all too prevalent in the past, would be disastrous. The Welsh Seed Growers' Societies are concerned almost entirely with growing Aberystwyth strains of pedigree and bred strains. These have been bred to suit different soil and climatic conditions and for high productivity, and, in the case of grasses and clovers, for persistence.

Seed production in suitable areas can, therefore, confer a threefold benefit on Welsh farming:

1. by providing specialized seed growers with a remunerative enterprise;
2. by making available to the generality of farmers healthy and highly productive pedigree seeds which would enable the average farmer to use his land, labour and capital in the most efficient way.
3. by developing an export market in seeds in English areas where there is already a large and unsatisfied demand for them.

A twenty-fold increase in seed production in Wales would not strain the existing markets, and the Principality should not allow this opportunity to go by through apathy.

*A step forward has been taken in the promotion of seed growing in Wales by the formation of a joint Seeds Committee comprising representatives of the Welsh Seed Growers' Federation, the National Agricultural Advisory Service, the National Farmers' Union, the Welsh Plant Breeding Station, the Department of Agricultural Economics, U.C.W., Aberystwyth, and the Welsh Agricultural Organisation Society. This Committee has already met three times and drawn up a programme of work, which will be largely in the hands of the Seed Promotion Officer, Mr. G. Gordon Owen, who took up his duties on the 1st Nov., 1946.—Rural Wales, Vol. 2, No. 3.

WELSH SEED GROWERS' SOCIETIES, MEMBERSHIP AND ACREAGES, 1944.

Name of Society	Counties served	Registered	Member-ship	Acreage				
				Cereal	Grasses	Clover	P'toes	Total
1. North Wales Seed Potato Growers	Anglesey, Caernarvon Denbigh Flint Merioneth	April, 1933	150				382	382
2. Crymmych Seed Potato Growers	Pembrokeshire Cardiganshire	July, 1939	78				388	388
3. Hay Talgarth Seed Growers	Brecon Radnor	Sept., 1939	41	713	213	80		1006
4. Clarach Seed Growers	Cardiganshire	March. 1940	71	451	37			488
5. Vale of Clwyd Seed Growers	Denbigh Flint	October, 1941	75	44	46	16		106
6. Powysland Seed Growers	Montgomery	March, 1940	70	131	131	21	254	537
7. Pembrokeshire Seed Growers	Pembrokeshire	March, 1942	51	358	197	10		565
8. Monmouthshire Seed Growers	Monmouthshire	May, 1942	29	218	116	91		425
9. Myrddin Seed Growers	Carmarthenshire	May, 1942	10					
10. Glamorgan Seed Growers	Glamorgan	April, 1943	31	133	25	71		229
11. Brecon-Radnor Seeds, Ltd.	Brecon Radnor	October, 1943	15				256	256
12. Montgomery Late Flowering Red Clover Society	Montgomery		97			310		310
		Total	727	2048	765	599	1280	4692

Grassland Research and Advisory Work in Sweden

A special Jubilee Number of the *Svenska Vall- och Mosskulturföreningens Kvartalsskrift* (Vol. 8, Nos. 2 and 3, 1946) has been published to commemorate the completion of 60 years work (1886-1946). Until 1939 the work under review was conducted by two organizations, Svenska Betes- och Vallföreningen and Svenska Mosskulturföreningen, but in that year they were amalgamated to form the Svenska Vall- och Mosskulturförening (Swedish Grassland and Peat Society).

The following are the translated titles of the main contributions :

Svenska Betes- och Vallföreningen. A retrospective survey and some reflections. A.Elofson.

The work of Svenska Mosskulturföreningen and Svenska Vall- och Mosskulturföreningen 1886-1946. G. Rappe.

Problems and investigations in the sphere of pasture cultivation. G. Giöbel.

Experimental and research work of the Bog Department of Svenska Vall- och Mosskulturföreningen and Svenska Mosskulturföreningen during the last ten years. G. Rappe.

The work of the Chemical Laboratory. H. Hjertstedt.

The botanists and their work. G. Sandberg.

Advisory work in the pasture sphere. J. Borg.

Advisory work of Svenska Mosskulturföreningen. Historical review. O. Djurle.

General pasture control, farm control and cultivation trials in Norrland. B. Wallin.

Duties prescribed by law and conservation of fencing posts. J. Borg.

Advisory work in Norrland : experiences and observations. B. Ahlström.

Some impressions of the work of an adviser in the Bog Department. S. Olofsson.

Settling and draining of peat soils—manuring of peat soils. O. Djurle.

Condition of the organogenic cultivated soils in different provinces in regard to kind of peat, degree of humification and reaction, and also to content of lime and nitrogen, potash and phosphoric acid, organic matter, sesquioxides and sulphuric acid. H. Hjertstedt.

The report presented by Dr. Gunnar Giöbel is divided into two main sections : the first relates to questions concerning the preparation, establishment and maintenance of pastures, the second to the utilization of pastures, the technique of grazing and the economics of management.

Experiments on the eradication of heather, bilberry and other undesirable vegetation by means of potassium and sodium chlorate were initiated in 1942 and 1943 with the object of preparing ground for the cultivation of pasture. The method may also be of value for the control of weeds in pastures. The Society hopes that in connexion with an investigation of the forest question in Norrland it will be able to conduct comparative experiments with different methods of cultivation in the establishment of cultivated pastures.

A comprehensive study of the best method of supplementary sowing of older leys and wooded grazing ground was initiated at many centres in the province of Uppsala in 1943. The main problems are the best method of preparing ground by cultivation, liming and manuring (and possibly also draining) before establishment, together with the best procedure in sowing (broadcast or in drills, with or without rolling), in addition to the possibility of covering the surface of the ground with farmyard manure, compost or straw or other similar material.

Comparative trials with different species and strains in pure plots as well as a number of trials with very simple mixtures (for example, *Trifolium repens* + *Poa pratensis*) were conducted from 1933 to 1938, mostly in collaboration with Sveriges Utsädesföreningen (Swedish Seed Association). Results have been collated and are available for study. A report on the trial for the standardization of seeds mixtures for different climatic zones has been published in *Svensk Frötidning*, 1939, No. 1, p. 1. Three methods for the experimental determination of the yield of pastures have been tested : the use of control cages, frame sampling, laying out of trials with two or more replicates which are alternately grazed and mown. Results have been published in Meddelande No. 2 of Svenska Betes- och Vallföreningen 1933, in Nordisk Jord-

bruksforskning, (Congress report 1935, pp. 820-837) and in Bulletin 28 of the Bureau of Pastures and Forage Crops, 1940.

Investigations have been conducted on seasonal variations in growth of pastures and the factors which influence them, as well as methods of remedying the unfavourable conditions by, for example, applying quick-acting nitrogenous fertilizers at certain periods of growth, and also by irrigation and the correction of the humus content of the soil. Results have been published in the Society's Kvartalsskrift, 1945, p. 298.

Control of the yield of pastures was initiated by the Svenska Betes- och Vallförening in 1924 and the results were published in the Society's year-books for 1925, 1927, 1929, 1931, 1933 and 1935 and in the Kvartalsskrift of the Svenska Vall- och Mosskulturförening 1939, No. 2. Reports have been published in Medd. No. 1, 1932 and No. 4, 1934 of the Svenska Betes- och Vallförening, also in the year-books for 1933, 1934, and 1936.

Bror Wallin states that controlled grazing was included in the Society's programme in 1924. Special note-books were prepared and so arranged that the yield of the pastures could be calculated in fodder units according to Nils Hansson's norms. The note-books were distributed to farmers interested in the control in question who co-operated in this work during 1924, and results were published in the Society's year-book for 1925. The report was concerned with 131 hectares of pasture land studded with trees and bushes, and 135 hectares of pasture leys on arable land distributed among fifteen large estates in south and middle Sweden. The 1924 results were as follows :

	Fodder units per ha.
Unmanured pasture-ground studded with trees and bushes	325-900
Manured ,, ,, ...	775-2260
Pasture leys on arable land	1650-4100

The Society continued to be concerned with this controlled grazing for ten years, and at the end of that time a review of the work and a summary of the results were published in the 1935 year-book. The Society's note-books for recording data relating to controlled grazing are still used by a large number of farmers.

In 1931 the Society initiated farm control at Boda in Närke, and at Blombacka in Västergötland, and this was continued until the amalgamation of the Swedish Grassland Society with the Society for the Cultivation of Peat-land. An account of the work at the control farms was published in detail in Medd. Nos. 1 and 4 of Svenska Betes- och Vallföreningen and in summarized form in the Society's year-books for 1933, 1934, 1936, 1937 and 1938.

The Society also arranged cultivation trials at two centres in Norrland designed primarily to compare surface and deep cultivation of the ground when establishing pastures on uncultivated land. These experiments were conducted with young animals which were weighed regularly ; the yield was computed in fodder units. The following average figures of fodder units per hectare for the years 1933-1936 indicate the yield from cultivated pasture in Norrland :

	Nordvik	Spöland
Deep cultivation..	3,493	2,463
Surface cultivation	2,653	1,856

A report on the experiments was published in Medd. No. 3, 1934, and also in the year-books for 1934 and 1936.—R. Peter Jones.

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Birdsfoot Trefoil as a Forage Legume

In Memoir No. 261 of the Cornell University Agricultural Experiment Station, Dr. H. A. MacDonald brings together a great deal of information on birdsfoot trefoil, *Lotus corniculatus* L., a leguminous plant which has until recently received very little attention or study in the United States. The need for a perennial legume more persistent than red clover or alfalfa and more drought resistant than white clover has seemed sufficient reason to conduct an investigation of this crop. The first portion of the text of this report deals with a general description of the plant and its growth and development from seed germination to maturity. Some attention is given to the history, distribution, and adaptation of birdsfoot trefoil throughout the world.

The latter part of the Memoir is concerned with the value of birdsfoot trefoil as a possible forage crop for the dairy regions of the north-eastern United States. The preliminary results of investigations conducted throughout the State of New York, and particularly at Cornell University, are presented in an attempt to determine the desirable and undesirable qualities of the plant and its method of management. The range and limits of MacDonald's work and the plan adopted are indicated by the following table of contents :—

	Page
The birdsfoot trefoil plant	8
The seed	8
Germination and the seedling	11
The root system	14
The stem and leaf	23
The inflorescence and flower	32
Flowering and pollination	38
Classification	44
Birdsfoot trefoil as an agricultural plant	48
History	48
Ecology	53
Soil adaptation and fertility requirement	58
Seeding and seeding management	80
Cultivation of birdsfoot trefoil for hay	95
Cultivation of birdsfoot trefoil for pasture	117
Use of birdsfoot trefoil in land renovation	125
The palatability of birdsfoot trefoil	127
Cyanophoric properties of birdsfoot trefoil	129
Chemical and feedstuff analyses	130
Seed production	138
Insect pests	156

A good indication of the results obtained to date is given by the following adapted quotation of the twenty-eight points of the author's summary.

Lotus corniculatus L. is a long-lived perennial of possible agricultural value in the State of New York. The crop is slow to establish and may be severely injured where unfavourable conditions exist during the seeding year. When well established, birdsfoot trefoil is adapted to a wide range of soil types and soil-moisture conditions. The narrow-leaved variety is better suited to moist conditions than the broad-leaved type.

For nitrogen fixation, birdsfoot trefoil requires a symbiotic rhizobium species

different from that of the common legumes. The response of this legume to fertilizer treatment resembles that of other common legumes, but birdsfoot trefoil can persist and produce at lower fertility levels than the other forage legumes. The soil-lime requirement is less than that required for alfalfa. This difference appears to be correlated with variations in type of root system. The deep root system of birdsfoot trefoil together with its profuse branching in the upper soil zone appears to give a definite advantage over a wide range of conditions.

After establishment, birdsfoot trefoil is more drought resistant than shallow-rooted legumes such as white clover. Spring sowing of the trefoil under New York conditions is superior to autumn sowing. A depth of sowing of one-fourth to one-half inch was superior to shallower or deeper sowings. No improvement in yield was obtained in sowing at rates greater than 5 pounds per acre, where good soil preparation can be obtained and where growing conditions are favourable. The use of a cereal companion crop retards seedling establishment ; when used, a rate of sowing below normal for the companion crop is desirable.

Birdsfoot trefoil is generally lower in yield for hay than alfalfa on soils adapted to the cultivation of alfalfa, but on soils unsuitable for alfalfa the trefoil is more persistent and gives a higher forage yield. Red clover normally gives a higher yield in the first harvest year, but does not persist beyond that year in any appreciable quantity ; birdsfoot trefoil persists and continues to produce as a perennial.

The stem of the trefoil is weak and it is desirable to sow this legume with a strong supporting grass to prevent lodging. Plants offering excessive competition in mixtures are distinctly detrimental to the maximum production of this crop. For pasture use, birdsfoot trefoil gives best results when sown with an open sward-producing grass such as *Poa pratensis*, *Phleum pratense*, or *Dactylis glomerata*.

Birdsfoot trefoil compares favourably with wild white clover as a pasture legume during the years in which it was tested. It remains green in the autumn for several weeks after the other legumes have been severely injured and defoliated by frost. This would indicate its further use for late autumn grazing. MacDonald considers that birdsfoot refoil is promising for the renovation and maintenance of marginal and submarginal land.

Birdsfoot trefoil compares well in palatability with other legumes of similar nature and stage of maturity. Chemical analyses indicate that so far as nitrogen, calcium, phosphorus and lignin are concerned the trefoil is equivalent in nutritive value to alfalfa for hay and white clover for pasture. The cyanophoric properties of birdsfoot trefoil vary but in no case is any harmful effect produced nor HCN poisoning found where stock are fed on this crop.

The production of seed of birdsfoot trefoil is one of the major problems retarding its use as an agricultural crop. The mature legume of the trefoil shatters readily, necessitating great care in handling to prevent undue loss of seed. Few insects or diseases seriously affect the trefoil. A number of superior strains have been selected and selection and breeding are considered to be two of the most promising means of improving the crop.

In general the results of this study are considered to indicate that birdsfoot trefoil shows enough desirable characteristics to warrant further investigation and improvement. It cannot be expected to compete with such crops as alfalfa or red clover for hay production on the better soils and under a short-rotation system of

farming. It does, however, present distinct possibilities for hay and pasture production on secondary or poorer soils where alfalfa is not successful, where red clover is too short-lived for the rotation used, and summer conditions too dry for the persistence of white clover.—R. O. Whyte.

Hay Dehydration in the Southwestern United States

The modern method of preparing alfalfa for live-stock and chicken feed is, according to J. A. Leveritt in *Reclamation Era* for December, 1946, being used for the first time in the Southwestern United States on the Bureau of Reclamation's Yuma project near Blaisdell, Arizona. The dry desert air of Arizona increases the efficiency of the dehydrating plant, making the operation even more successful than in other parts of the United States.

Early in 1946 the Company concerned with this work moved a dehydration plant from Charleston, Missouri, to Blaisdell, where it has since been in constant operation. The plant has a rated capacity of 20 tons every 24 hours, but the extremely dry air of the desert has made it possible to deal with as much as 30 tons per day. The operation of the plant in Gila Valley of Arizona is also advantageous in that the growing season there is 12 months in duration, permitting operation of the plant throughout the year. In this way the cost of the plant can be amortized in a much shorter time.

A complete change in marketing alfalfa has become necessary for the farmers who sell their crop to the operating company, and there is still a considerable debate among them as to the relative economy of dehydrating the hay or selling it in the conventional way.

First with regard to the dehydrating process itself, the hay is dried by hot air, which is heated in a fuel-oil furnace to a temperature of 1200—2000°F., depending on the moisture content of the crop. Suction fans draw the heated air and the hay, specially chopped for the process, into a 25-foot drum. This drum is divided into three sections and the hay therefore actually travels 75 feet in the drum and remains there for 3 to 5 minutes. It leaves the drum at a temperature of 250 to 300°F. From the drying drum it travels through two cyclone dust collectors where it is cooled and the air separated from the hay. The second dust collector feeds the hay into a hammer mill where it is ground into a fine green flour. This flour goes to a third dust collector and the air is separated from the ground alfalfa. It is then packed in 100 lb. bags for shipment. This method preserves much of the food value of the hay which would otherwise be lost, and particularly the vitamin content.

Normally the farmer cuts his alfalfa, dries it in windrows, and then sells the baled hay. The hay which is to be used for dehydration purposes is sold uncut in the fields for about 20 per cent less per ton. One farmer recently carried out a small trial on the relative returns from the two methods of utilization. He sold 60 acres of alfalfa to the operating company, and at the same time harvested 60 acres himself. The company completed its cutting operation in 4 days, and on the fifth day the field was irrigated and another crop started. It required 12 days to cut, dry, and bale

the hay from the other 60 acres in the conventional way. The tonnage from both fields was approximately the same.

At the time the price in Yuma for the baled alfalfa was $28 a ton and the operating company was paying $22.50 a ton. The farmer decided that the returns from the two fields would be about the same, considering the savings in harvesting, and the 8-day growing start obtained by the alfalfa in the field cut by the operating company. Those farmers who do not support the dehydrating process argue that the return from baled hay is greater. Another argument brought forward is that operations when cutting the crop for dehydration damage the borders round the field, making it necessary to repair them before water can be applied to start the next crop of alfalfa under way. Regardless of the economics of the dehydrationg process, the company has been able to purchase all the alfalfa which the plant can process.

R. O. Whyte.

U.S. Regional Pasture Research Laboratory

Dr. R. J. Garber, the Director of the Laboratory, described its formation and the scope of its work in *Herbage Reviews* 6. 146-50. 1938. The Pasture Research Laboratory located at State College, Pennsylvania, is one of nine such laboratories, the other eight being as follows :

U.S. Regional Vegetable Breeding Laboratory, Charleston, S.C.
U.S. Regional Soybean Laboratory, Urbana, Ill.
U.S. Regional Swine Breeding Laboratory, Ames, Iowa.
U.S. Western Sheep Breeding Laboratory, Dubois, Idaho.
U.S. Regional Animal Disease Research Laboratory, Auburn, Ala.
U.S. Regional Poultry Research Laboratory, East Lansing, Mich.
U.S. Regional Salinity Laboratory, Riverside, Calif.
U.S. Plant, Soil, and Nutrition Laboratory, Ithaca, N.Y.

Each deals with a problem or group of problems considered in consultation with the State Experiment Stations to be the most important faced by agriculture in that section of the country.

A report has now appeared in the form of U.S. Dept. Agric. Misc. Publ. No. 590, Feb. 1946, covering the complete research programme, results obtained to date and the continuing research at the Pasture Research Laboratory.

This Laboratory was established at State College, Pa., in 1936, to work in co-operation with the twelve States, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland and West Virginia. The Laboratory is under the administrative direction of the Division of Forage Crops and Diseases of the Bureau of Plant Industry, Soils, and Agricultural Engineering. The Laboratory itself as well as the co-ordination of co-operative work with the twelve experiment stations is under the immediate control of the agronomist as director and the staff includes a geneticist, biochemist, plant physiologist, plant pathologist, soil specialist, and a number of assistants. To facilitate the planning, co-ordination, and integration of fundamental research at the Pasture Laboratory and the agricultural experiment stations, a group of collaborators

was appointed in 1936, one staff member being assigned from each of the above twelve stations. These collaborators represent most of the fields of research allied to the pasture problems in the regions.

Productive pastures and other grasslands are important to prosperity and health in the north-eastern region where climate, soils and economic conditions are well suited to grassland agriculture. Dairying is the source of more than a third of the cash income of the farmers in the north-eastern United States, a section which produces over 2 billion gallons of milk a year. More milk and milk products are needed, however, to provide an adequate level of nutrition for the people of the region. To increase production of these foods in the north-east will require more and better dairy cows, and to maintain these animals larger supplies of home-grown feed and particularly pasturage will be needed.

Establishment, Fertilization, and Management of Pastures

The ideal system of pasture management in the north-eastern region would result in the maintenance of approximately equal proportions of Kentucky bluegrass (*Poa pratensis*) and white clover (*Trifolium repens*). In order more nearly to approach this ideal it is necessary to know more about the interrelated effects of liming, mineral and nitrogen fertilization, grazing management, soil moisture and various climatic factors, particularly high soil and air temperatures. The Pasture Laboratory is now engaged in both greenhouse and field studies to determine why white clover persists in association with Kentucky bluegrass in some instances and will not do so in others. Experiments are also in progress to determine the feasibility of supplementing the nitrogen supplied by the clover with nitrogen fertilization without materially decreasing the amount of white clover in the pasture. Studies have shown that the tendency of nitrogen fertilizer applied in spring to stimulate the grass in a grass/clover association so that it crowds out the clover can be counteracted by grazing the grass closely until the clover has an opportunity to start growth. This system of fertilization and management gives high yields in the spring but is less favourable to the grass during the hot summer, when clover seems better able to compete with grass provided adequate moisture is available. Both Kentucky bluegrass and white clover are relatively shallow-rooted and are usually unproductive during July and August. Irrigation during these months has produced excellent growth and may be indirectly a factor in supplying the nitrogen needs of the pasture. This possibility needs further investigation, and studies are also required to determine whether the increased production will ever be great enough to justify the expense of irrigation.

Research is also concerned with the attempt to introduce larger, deeper rooted species capable of growth during the dry periods of mid-summer, and in this connexion cocksfoot, brome grass, Ladino clover and alfalfa appear to be most promising, while other species of possible value include reed canary grass, tall oat grass, tall fescue and birdsfoot trefoil. It was at first thought that these larger herbage plants could be used only on arable land as part of the rotation, but it has now been discovered that they can be established in old pasture areas by renovation.

Other items covered in this section of the report deal with the use of the bog harrow for preparing the seed-bed, and the harmful effects of heat on newly sown pastures. The climatic control chambers at the Pasture Laboratory have provided the means of determining the effects of air and soil temperatures on the establishment

and growth of varieties of the grasses and legumes under test. Some species are particularly sensitive to hot weather, others such as alfalfa, alsike, cocksfoot, and bromegrass are less so.

Throughout much of the north-east, red clover, alsike, and timothy are used in the standard hay mixture, but cocksfoot and Ladino clover are now found to be promising, especially when used for early-cut hay or grass silage and late-season pasture. The mixture requires a good level of fertility. The maintenance of this combination of cocksfoot and Ladino clover in a highly productive condition with a proper balance of grass and clover is one of the major problems of management and again the climatic control chambers are providing answers to the questions which arise.

Alfalfa in combination with bromegrass or cocksfoot is better adapted than Ladino clover for use as hay, since the alfalfa grows erect and is thus better able to compete for light. Grazing of the alfalfa, however, must be controlled to prevent continuous removal of the leaves and stems and to allow sufficient time for recovery between grazings. Birdsfoot trefoil is another legume that has shown promise in parts of this region (see separate review in this bulletin).

While considerable progress has been made in providing a supply of nutritious pasture herbage throughout the season many problems remain unsolved. An example is the maintenance of high-producing intensively managed pastures over periods of more than 3 or 4 years. While this may be long enough for rotation pastures, it is usually desirable to maintain renovated pastures in a productive condition as long as possible rather than risk the hazards and incur the expense of re-establishment. Undoubtedly part of the reduction in productivity as the sward becomes older is due to a decrease in the availability of certain fertilizer elements. It also appears that the invasion of Kentucky bluegrass may be affected. For the solution of these and other problems, fundamental information on the relationships of light, temperature, moisture, frequency of defoliation, height of cutting, etc. is essential.

Chemical Problems

One phase of the chemical studies at the Pasture Laboratory concerns the carbohydrates of grasses and an important factor in these studies has been improvement in methods of analysis. Better methods have been worked out for the analysis of the simple carbohydrates so that the various sugars can be distinguished from one another; the same is true for two of the more complex carbohydrates, fructosan and cellulose. The importance of carbohydrates to practical pasture problems is primarily as reserve or stored substances. Evidence has been obtained that the sugars and fructosan are stored in the lower stalks and roots of the plant and are therefore not completely removed by grazing. Plants with large amounts of stored carbohydrates can make better recovery after severe and frequent grazing.

The other aspects studied include analysis for vitamins, proteins, and toxic substances and the preparation of proteins from grass for use in protein-concentrate feeding stuffs for live stock.

Breeding

Sustained production of new varieties from year to year will be an important factor in providing more adequate and more economical food. For this purpose the varieties must be (a) winter hardy enough to survive even the most severe winters,

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(b) resistant to the more important diseases which may seriously affect yield and quality of forage, (c) tolerant to drought and floods, and (d) able to withstand periods of too little or too much grazing. The plant breeder must adapt his new varieties to mechanized operations, just as the grain-sorghum breeder has so successfully done in producing varieties adapted for combine harvesting.

The steps taken in breeding new varieties of grasses and legumes are : collection of material and planting as single plants in nurseries, clonal increase, further tests of selected plants, synthesis of new strains, production of inbred lines, hybridization, evaluating new strains prior to distribution for general use. Improved varieties of the following species are mentioned : *Poa pratensis*, *Dactylis glomerata*, *Trifolium repens* (white and Ladino) *Phleum pratense*, *Trifolium pratense*, *Agrostis* and *Medicago sativa*.

In addition a number of fundamental investigations are in progress in relation to breeding these grasses and legumes more particularly with regard to the study of the inheritance of self- and cross-fertility, self- and cross-sterility, disease resistance, earliness, winter hardiness, chemical composition, vigour, and the behaviour of the chromosomes during mitosis and meiosis.

Disease Problems

The final section of the report deals with a study of various diseases of herbage plants and the production of resistant lines, also studies of seed treatments to reduce damping-off.

On pp. 27-29 of the report there appears a complete list of all the papers published from the Pasture Research Laboratory since it was founded in 1936 to date.

Pasture Investigations in Victoria

Pasture improvement work conducted by the Department of Agriculture in progress during 1944-45 is reported by W. D. Andrew, Agrostological Research Officer, in the *J. Dept. Agric. Vict.* Vol. 43. 453-8 and 490-4. 1945, and Vol. 44. 3-11 and 30. 1946.

Observational trials with species and fertilizers have been maintained at forty-five centres throughout the State, and increased attention is being paid to the development of pastures on poor land which embraces experiments with minor elements on deficient soils. Whether the area to be improved has a high soil fertility or a relatively low one, the superior strains are selected so as to provide a well-balanced pasture containing both grass and clover species.

Clovers. In nearly all parts of Victoria where the annual rainfall exceeds 20 inches *Trifolium subterraneum* is the chief foundation of improved pastures. Early varieties such as " Dwalganup " are most suitable in the short-growing-season districts, but farther south, where the rainfall is 25 inches or more, the " Mt. Barker " midseason variety is commonly used. " Tallarook " is a late-flowering leafy strain adapted to high rainfall districts and " Bacchus Marsh " is noted for its winter production.

Other clovers have been developed to suit various pasture conditions. Australian varieties of white clover (*T. repens*) are difficult to define, but " Mother " or " Pedigree " seed is well-fitted for permanent pasture establishment where the summer rainfall is good, and a special giant strain has been bred for areas under irrigation. On low-lying swampy land strawberry clover (*T. fragiferum*) is a valuable and persistent pasture legume and birdsfoot trefoil (*Lotus corniculatus*) is also useful as a pioneer species on waterlogged soils. Where good drainage occurs it is possible to grow red clover (*T. pratense*) and lucerne (*Medicago sativa*) for both grazing and hay, and the latter species is particularly desirable on alkaline soils.

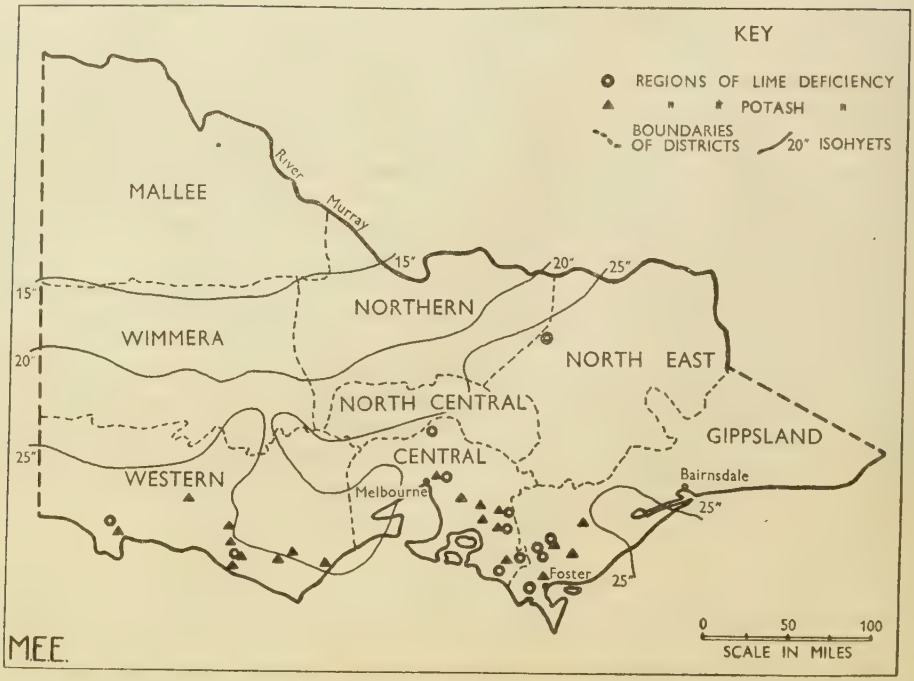
Grasses. The best and most generally used grasses are the ryegrasses. Different regional strains of *Lolium perenne* are available, and the Wimmera (*L. rigidum*) and Italian (*L. multiflorum*) types are widely adopted for temporary pasturage and colonization in the " Mediterranean " zones of winter rainfall and summer drought. Under these climatic conditions *Phalaris tuberosa*, when once established, proves a very successful permanent grass for sheep or cattle grazing. Cocksfoot (*Dactylis glomerata*) requires a high rainfall in summer and is primarily used for cattle. Where the land is swampy improvements can be made by introducing *Paspalum distichum* and " *Poa aquatica* " which both combine easily with the water-loving clovers.

Establishment and Maintenance of Pastures

Numerous trials have demonstrated the importance of preparing a good seedbed and using superior seeds at rates of sowing low enough to avoid undue competition. Subsequent careful grazing management is equally important if excessive defoliation or accumulation of rank growth are to be avoided. Under Victorian conditions an average resting period is provided by an interval of 4 to 5 weeks between grazings and any surplus pasture growth is conserved as pressed meadow-hay or silage.

The most urgent problem in maintaining soil fertility is to provide the improved pastures with sufficient superphosphate, since nearly all Victorian soils are phosphate-deficient. Trials have shown that 1 to 2 cwt. per acre annual applications of superphosphate are most economic in the normal rainfall areas and applications of 4 cwt. per acre are profitable on irrigated land. On some soils about 40 per cent of the phosphate applied remains as a residuum in the soil, so that liberal top dressing, repeated over a number of years, builds up a phosphate reserve. If these applications of fertilizer are either stopped or reduced the effect on pasture growth is not immediately visible, but after the first year a gradual decline sets in, which later accelerates as the phosphate reserves become more depleted.

Many localities south of Melbourne show signs of potash and lime deficiencies. Although potassic fertilizer is expensive, experiments have justified the use of about 0.5 cwt. per acre under existing economic conditions. The lime-deficient soils of Gippsland with pH values as low as 5 are an exception in Victoria. They respond to all forms of calcium compounds and the resulting increases in legume development from small applications are very satisfactory, and are even more well-marked when inoculated seeds are employed. All these different fertilizers are useful top dressings for restoring particular mineral elements to deficient soils, but the amounts required can be minimized by using farmyard manure to keep the grasslands in good condition.



Agricultural Districts of Victoria

Pasture Improvement

Experimental plots are conducted by the Department of Agriculture for the Victorian Pasture Improvement League on both non-irrigated and irrigated pastures. The following are reports of work in the different districts of the State.

Gippsland. Good soil and adequate rainfall are characteristic over most of this country, which is highly suitable for perennial ryegrass, subterranean and white clover pastures. In the drier areas south-west of Bairnsdale, *Phalaris* is more permanent while the *Paspalum* spp., strawberry clover and birdsfoot trefoil are well-suited to wet places. On some of the less fertile soils kikuyu grass (*Pennisetum clandestinum*) is favoured as a summer-growing fodder.

There is a stretch of coastal country west of Foster which offers unique improvement problems as the soils are generally poorly drained and very acidic. The natural vegetation of low dense scrub is easily ploughed under and the soil is sweetened by growing oats before establishing a pasture. On such soils as little as 2 cwt. of lime per acre produces a marked response. It is necessary to inoculate the legume seed for good results and then, as the fertility is improved by top dressing with lime and superphosphate, a dense sward of ryegrass and subterranean clover is obtained.

Occasionally *Paspalum* invades Gippsland pastures and makes them sod-bound and unpalatable. This is remedied by mowing or, where the condition is more serious, by breaking the soil during autumn and sowing down perennial ryegrass,

subterranean and white clovers. For the control of cockchafers, however, a certain amount of *Paspalum* in the sward is beneficial since it maintains a closed stand and helps to resist these grass grubs which are common in the south of Victoria.

Western District. Top sowing works well on the typical plains country whose carrying capacity is about three dry sheep to 4 acres. The mixture used consists of 3 to 5 lb. of perennia lryegrass with 3 lb. of subterranean clover which is worked in with 1 cwt. of superphosphate per acre by means of a combine followed by a heavy chain. After carefully regulated stocking on the improved pasture the carrying capacity of this land is more than trebled. A more suitable permanent grass for the lighter soils is *Phalaris tuberosa* which can withstand the dried-out condition prevalent in summer. During the seeding year this grass is sensitive to competition, and the custom of sowing it on stubble, without a nurse or clover crop, produces desirable results. There are considerable tracts of stoney country in the Western District where rabbit control is vital before pasture improvement can take place.

Throughout the whole area the conservation of hay and silage to provide supplementary feed during lean periods is of the utmost importance. Suitable crops for this purpose are lucerne, rape, millet and maize. The most serious weed pest of renovated pastures is cape weed (*Cryptostemma calendulaceum*). Trials have shown that grasses such as *Paspalum*, *Phalaris tuberosa* and *Pennisetum clandestinum* are most appropriate for keeping the sward closed and free from cape weed and cockchafer grubs at the same time.

Central District. A wide range of soil and climatic conditions is a feature of this district. Insufficient soil moisture is a limiting factor in grassland development on parts of the western plains and low hill country, making pasture improvement a skilled technique. The more drought-resistant grasses are longer-lived in these areas than perennial ryegrass, and " Bacchus Marsh " subterranean clover is the safest legume. This is usually sown with the last cereal crop and *Phalaris* is introduced into the stubble a year later when the clover is well established. Superphosphate is necessary on all the soils and lime is beneficial to lucerne and pastures growing on Silurian outcrops. On some of the light grey Silurian soils there is also evidence of potash deficiency.

Towards the east of the central highlands the more pronounced winter period and consequent longer pasture dormancy makes fodder conservation very essential. The higher rainfall favours ryegrass, and *Secale cereale* provides a useful winter grazing crop.

North-Eastern District. Only a small area of this Victorian division has so far undergone any pasture improvement. Varieties of subterranean clover are easily established ; in general, the Mt. Barker mid-season strain is sown, but " Tallarook " and " Bacchus Marsh " are used on the more productive and less productive soils respectively. *Phalaris tuberosa* is the outstanding permanent grass in the north-east where it is established with subterranean clover by the same method as that described for the Central District. Except for the deep alluvial soils of river valleys, the ground is unsuitable for perennial ryegrass which at first grows well, but is subsequently ousted by unpalatable annuals. The characteristic lightness of the soil is counteracted by sowing seed and fertilizer at a depth of 0.5 to 0.75 in. on a prepared seed-bed.

Both lime and superphosphate have increased pasture production, but heavy

continuous grazing has resulted in many clover-predominant swards in the north-eastern district. A more strict grazing control is called for, not only to maintain production, but also to ensure vegetative stability in a district which contains some of the lightest soils of Victoria.—M. E. Edwards.

Grass Productivity Studies in a Tropical Lowland

The Effects of Season and Frequency of Cutting on the Productivity of Grasses in Queensland

Lack of knowledge concerning the most suitable herbage species for use in the tropical coastal belt of northern Queensland led to preliminary surveys with numerous introduced grasses and legumes in order to discover those most satisfactory for the environment. The chosen plants were tested under controlled conditions of grazing and results were published in 1941.

Further studies were initiated to ascertain the effects of seasonal influences and cutting treatments on the productivity of a selected number of grasses whose protein and mineral contents and yields under the different treatments were also determined. This work, carried out at the Bureau of Tropical Agriculture, South Johnstone, is reported by J. L. Schofield in the *Qd. J. Agric. Sci.* Vol. 1. Pt. 4. pp. 1-58 (1944), Vol. 2. Pt. 4. pp. 209-43 (1945), and Vol. 3. Pt. 1. pp. 44-79 (1946).

The site selected as an experimental area had been cropped with sugar cane for about 15 years. Soil acidity was corrected by liming, and a basal fertilizer dressing helped to restore soil nutrients. The grasses were arranged in three series to facilitate cutting, weighing and analysis. Each species was cut at the height to which it would normally be grazed, as follows :—

	Height of cut (inches)
Series I	
**Cenchrus ciliaris*	2
Digitaria milanjiana	2
**Panicum maximum* Jacq. No. 1202 (Hawaiian strain)	12
**Panicum maximum* Jacq. No. 3783 (Hawaiian strain)	6
Panicum maximum Jacq. var. *trichoglume*	4
Paspalum dilatatum	2
Urochloa bolbodes	2
Series II	
Brachiaria decumbens	2
**Brachiaria purpurascens*	2
Chloris gayana Kunth. No. 6586	4
**Cynodon plectostachyum*	2
Hyparrhenia aucta	2
**Panicum maximum* Jacq. No. 1200 (Hawaiian strain)	8
Panicum maximum Jacq. var. *coloratum*	4
Series III	
Chloris gayana Kunth. No. 6585	4
Melinis minutiflora	4
Panicum maximum Jacq. No. 3820 (Hawaiian strain)	4
Panicum maximum Jacq. var. *typica*	12
Pennisetum clandestinum	2

*Grasses marked thus were grown for 1 year only. The rest were grown for 2 years.

The duplicated plots used measured 30 ft. by 2 ft. and were divided into three sub-plots for cutting the grass at intervals of 30, 60 and 90 days. In order to avoid the decline in yield which is often observed during second-year cutting under temperate conditions, the sub-plots were fertilized after every cut made during the second year of harvest.

Effect of Season on Productivity

Following the period of establishment in the late summer of 1940, most grasses showed a phase of high productivity which was succeeded by a well-marked seasonal pattern of growth. This growth cycle begins with a "low productivity" period from July till October, corresponding with the winter "dead season". From November to December there is a "rapid increase" of yield which reaches its "zenith" period of high productivity from January to March. In the fourth period the herbage yield shows a "rapid decrease" lasting from April to June after which the "low productivity" period starts the herbage cycle for a second time. Two grasses which do not show this typical rhythm of growth are *Hyparrhenia aucta* and *Melinis minutiflora*.

Environmental factors that can affect the growth pattern are rainfall, temperature, and length of day. In Queensland, the wet season occurs when temperatures are high and the south-east trade winds are persistent, so that evaporation is rapid. This time of year marks the peak of grass production. However, the extremely high soil moisture content in autumn, due to the cumulative effect of heavy rainfall and decreased daily temperatures probably limits grass productivity during this "rapid decrease" period.

Effect of Frequency of Cutting on Productivity

Monthly Cuts. During the first 12 months the yield of green matter in tons per acre, together with the dry-matter percentage and yield, was obtained for each cut of every grass. By means of the analysis of variance the total yields of all the grasses were compared and a summary of the most productive grasses is given in the following table :—

Table 1.

	Mean yield of green matter (tons per acre)
Brachiaria decumbens	33.3
Panicum maximum No. 1202	28.3
Hyparrhenia aucta	28.3
Panicum maximum No. 3820	26.2
Panicum maximum var. *typica*	23.7
Urochloa bolbodes	22.9
Panicum maximum No. 3783	21.8
Melinis minutiflora	20.5

The most notable feature of the thirteen grasses grown during the second year was their marked falling off in productivity until the end of October. The rapid increase in yield occurring from November onwards was attributed to the fact that fertilizer applications were beginning to take effect, and this was very conspicuous with regard to *Panicum maximum* var. *typica*, which actually increased its yield over that of the first 12 months. This grass gave 34 per cent of its total yield for 2 years during the "zenith" period (Jan.-Mar.) of 1942. In contrast, *Chloris gayana* No.

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READING UNIVERSITY
ENGLAND.

6586 sustained a 65 per cent reduction in yield in the second year of growth, thus indicating its unsuitability to the wet tropical environment.

Two-Monthly Cuts. All the grasses, except *Hyparrhenia aucta*, exhibit the same four productivity phases under the two-monthly cutting system as those already described for the monthly cutting rotation. The behaviour of *Melinis minutiflora* towards the lower cutting frequency is in common with that of the other grasses; that is, its productivity curve shows a reduction in yield from June onwards.

Table 2 shows the highest-yielding grasses in the first 12 months of two-monthly cutting.

Table 2.

	Mean yield of green matter (tons per acre)
Brachiaria decumbens	45.5
Hyparrhenia aucta	31.9
Panicum maximum No. 1202	30.2
Panicum maximum No. 3783	27.2
Panicum maximum No. 3820	26.9
Urochloa bolbodes	26.7
Panicum maximum var. *coloratum*	24.1
Chloris gayana No. 6585	21.7

By comparing the above figures with those given in table 1 it will be seen that, in general, the longer cutting rotation gives higher yields of green matter than the monthly cutting. Exceptions are provided by the *typica* and *trichoglume* varieties of *Panicum maximum*, yields of which are depressed under the less frequent cutting system by 17 per cent and 21 per cent respectively.

Data of the second year's growth reveal the same general decrease in yield which was noted for the monthly cutting rotation. Again, the reaction of *Panicum maximum* var. *typica* towards fertilizer is marked and *Digitaria milanjiana* also shows a strong response.

Three-Monthly Cuts. Since each grass was cut only four times during the year under this rotation, the information obtained from a study of their productivity curves is restricted. However, with the exception of *Hyparrhenia aucta*, all the grasses show a marked decrease in yield from the first cut in midwinter to the second cut in spring. Thereafter more variation occurs in that some grasses give their greatest yield at the summer cut, while others reserve their maximum productivity until the autumn.

The total yields show a general increase over the monthly and 2-monthly cutting rotation figures. Yields of the most productive grasses are as follows:—

Table 3.

	Mean yield of green matter (tons per acre)
Brachiaria decumbens	53.1
Panicum maximum No. 1202	35.9
Panicum maximum No. 3783	31.1
Hyparrhenia aucta	30.0
Panicum maximum No. 3820	27.8
Panicum maximum var. *typica*	27.5
Urochloa bolbodes	26.6

Out of the nineteen grasses only four—*Panicum maximum* vars. *coloratum*, *trichoglume* and No. 1200, and *Cenchrus ciliaris*—show reductions in yield compared with monthly cutting. Whereas these reductions are all small, many of the increases due to 3-monthly cutting are substantial as in the case of *Brachiaria decumbens*, 59 per cent; *Chloris gayana* No. 6586, 53 per cent; *Melinis minutiflora*, 30 per cent; and *Brachiara purpurascens*, 28 per cent.

For all frequencies of cutting the yield totals exhibit a varietal effect which is highly significant. The most outstanding feature emphasized by the results is the higher rate of grass productivity which is induced by longer cutting rotations.

Variation in Yield in the Different Productivity Periods under a System of Monthly Cutting

As the number of days contributing to the different productivity phases varies from a maximum of 118 to a minimum of 58 days, a comparison of total yields during each period is rather misleading.

Instead, the yield in each productivity phase is expressed as the mean daily yield in pounds of green matter per acre over a period of 2 years. These figures for nine individual grasses are shown in table 4, together with the durations of the productivity periods and the amounts of rainfall received.

It will be noted that the range of variation under monthly cutting during the first year is comparatively small; the largest variation is shown by *Panicum maximum* var. *coloratum* with an increase of 435 per cent from the "low" yield of 34 lb. to the "zenith" yield of 182 lb. per day.

When the second 12 months are considered the variation among the data is much more pronounced. This is due on the one hand to the deleterious effect on yield produced by frequent repeated cutting and on the other to the stimulating influence of fertilizer which is clearly apparent in the "rapid increase" and "zenith" periods of productivity. Maximum variability is again displayed by *Panicum maximum* var. *coloratum* which has mean daily yields of 6 lb. in the "low" period and 254 lb. in the "zenith" period, equivalent to an increase in output of 41 times.

An interesting comparison can be made between the yields of the "zenith" periods in the first and second years. In this respect, *Panicum maximum* var. *typica* is outstanding among the Guinea grass varieties, showing as it does a 96 per cent increase (from 215 to 422 lb. per day).

General Pattern of Productivity. The variations of yield in the different productivity periods have already been shown for nine individual grasses in table 4. Excluding *Hyparrhenia aucta* and *Melinis minutiflora* for their exceptional behaviour, the average results of the seven grasses:—*Panicum maximum* vars. *trichoglume*, *coloratum* and *typica*, *Paspalum dilatatum*, *Brachiaria decumbens*, *Chloris gayana* No. 6586, and *Pennisetum clandestinum*—are given in the form of histograms, Figures A and B. In Fig. A the percentage contribution of each productivity phase to total production over a period of 24 months is shown together with a graph of the monthly rainfall. The mean daily yield data are presented in Fig. B which also shows average temperatures during the period of study.

TABLE 4.—SHOWING THE VARIATION IN THE DIFFERENT PRODUCTIVITY PERIODS OF MEAN DAILY YIELD (EXPRESSED AS POUNDS OF GREEN MATTER PER ACRE) OF INDIVIDUAL GRASSES UNDER A MONTHLY CUTTING ROTATION OVER A PERIOD OF TWENTY-FOUR MONTHS.

		Series I				Series II						Series III				
Productivity Period		No. Days growth	Inches of Rainfall	*Panicum maximum* var. *trichoglume*	*Paspalum dilatatum*	No. Days growth	Inches of Rainfall	*Hyparrhenia aucta*	*Panicum maximum* var. *coloratum*	*Brachiaria decumbens*	*Chloris gayana* No. 6586	No. Days Growth	Inches of Rainfall	*Pennisetum clandestinum*	*Panicum maximum* var. *typica*	*Melinis minutiflora*
After establishment	1st 12 months	89	31.55	223	133	91	31.94	94	146	318	128	90	26.92	99	196	102
Low	1st 12 months	118	8.65	51	40	118	4.79	143	34	99	40	118	5.31	57	43	119
Rapid increase	1st 12 months	58	5.57	96	64	60	6.22	214	136	173	57	59	9.33	64	189	189
Zenith	1st 12 months	90	65.83	154	120	90	81.07	278	182	263	100	89	103.43	107	215	131
Rapid decrease	2nd 12 months	90	75.96	41	46	89	60.81	25	28	57	20	90	35.02	35	32	50
Low	2nd 12 months	118	4.78	14	4	118	4.04	22	6	11	11	118	4.77	3	15	22
Rapid increase	2nd 12 months	59	8.01	130	43	62	8.24	168	104	152	40	61	8.03	47	225	138
Zenith	2nd 12 months	90	27.81	199	147	83	28.32	299	254	310	53	87	27.80	101	422	228

TABLE 5.—SHOWING SEASONAL VARIATIONS IN DRY-MATTER PERCENTAGE AND YIELD OF GRASSES UNDER A MONTHLY CUTTING ROTATION.

	1940				1941				1942
Date of Cut	Apr.-May	May-June	June-July	Oct.-Nov.	Jan.-Feb.	Apr.-May	July-Aug.	Oct.-Nov.	Jan.-Feb.
Mean dry-matter percentage	20.3	21.1	22.4	34.2	18.9	18.2	27.3	39.1	21.6
Mean yield of all grasses per cut in tons per acre	2.64	2.11	1.91	0.75	3.30	0.68	0.13	0.18	2.44
Mean daily rainfall in inches	0.57	0.32	0.26	0.06	0.40	1.22	0.25	0.04	0.13

From a consideration of these results the following conclusions regarding the general productivity pattern can be made :—

(1) There is a phase of high productivity immediately following the period of establishment, when this period occurs immediately before or at the commencement of the wet season.

(2) The division of each 12 months into four well-defined periods of productivity : " rapid decrease," " low," " rapid increase," and " zenith," described previously, is clearly demonstrated.

(3) There appears to be a positive correlation between yield and rainfall, temperature and length of day.

(4) A marked falling-off in yield is noticeable during the second 12 months from April to the end of October, in spite of a monthly application of superphosphate and blood (calculated on one-twelfth of the nutrients removed in the herbage during the first 12 months) added to the plots after each cut taken in the second year.

(5) A rapid increase of yield occurs from November onwards during the second 12 months as a result of fertilizer application becoming effective. During the dry winter period fertilizer showed no effect, but with the increase of temperature and rainfall during the spring and summer a marked uplift in yield is obtained.

Exceptions to the General Pattern of Productivity. The unusual character of *Hyparrhenia aucta* and *Melinis minutiflora* has already been noted in the yield data of table 4. Monthly cutting upset the regular growth rhythm of the latter grass, but after the first year and throughout the entire rotations under two-monthly and three-monthly cutting, its development was quite normal.

In contrast, the functional periodicity exhibited by *Hyparrhenia aucta* is unique. During the period following establishment, under a monthly cutting rotation, its mean daily yield of green matter is only 94 lb. per acre, while 143 lb. is the figure for the " low " period when the rainfall is considerably reduced (see table 4). This grass is again abnormal under two-monthly and three-monthly cutting rotations in which it shows no " low " period of productivity.

These results are important because they prove that, even under the rather extreme climatic conditions of coastal Queensland, it is possible for a grass to show exceptional behaviour to the normal growth rhythm exhibited by the majority of grasses. Although harsh and unpalatable, *Hyparrhenia aucta* is an introduction which bears a close resemblance to some of the native *Andropogoneae* and it may easily prove a valuable herbage contributor over a difficult portion of the year.

Variations in Dry-matter Content as influenced by Season and Frequency of Cutting

Dry-matter percentages of the various grasses were obtained for all cuts under each of the cutting rotations, and they reveal a marked seasonal fluctuation. In table 5 variations in the mean dry-matter percentage and mean green matter yield in tons per acre per harvest, obtained under the monthly cutting system, are compared with the different amounts of mean daily rainfall received.

These figures indicate the strongly negative correlation of dry-matter content with rainfall, and also the negative correlation of dry-matter with yield which exists

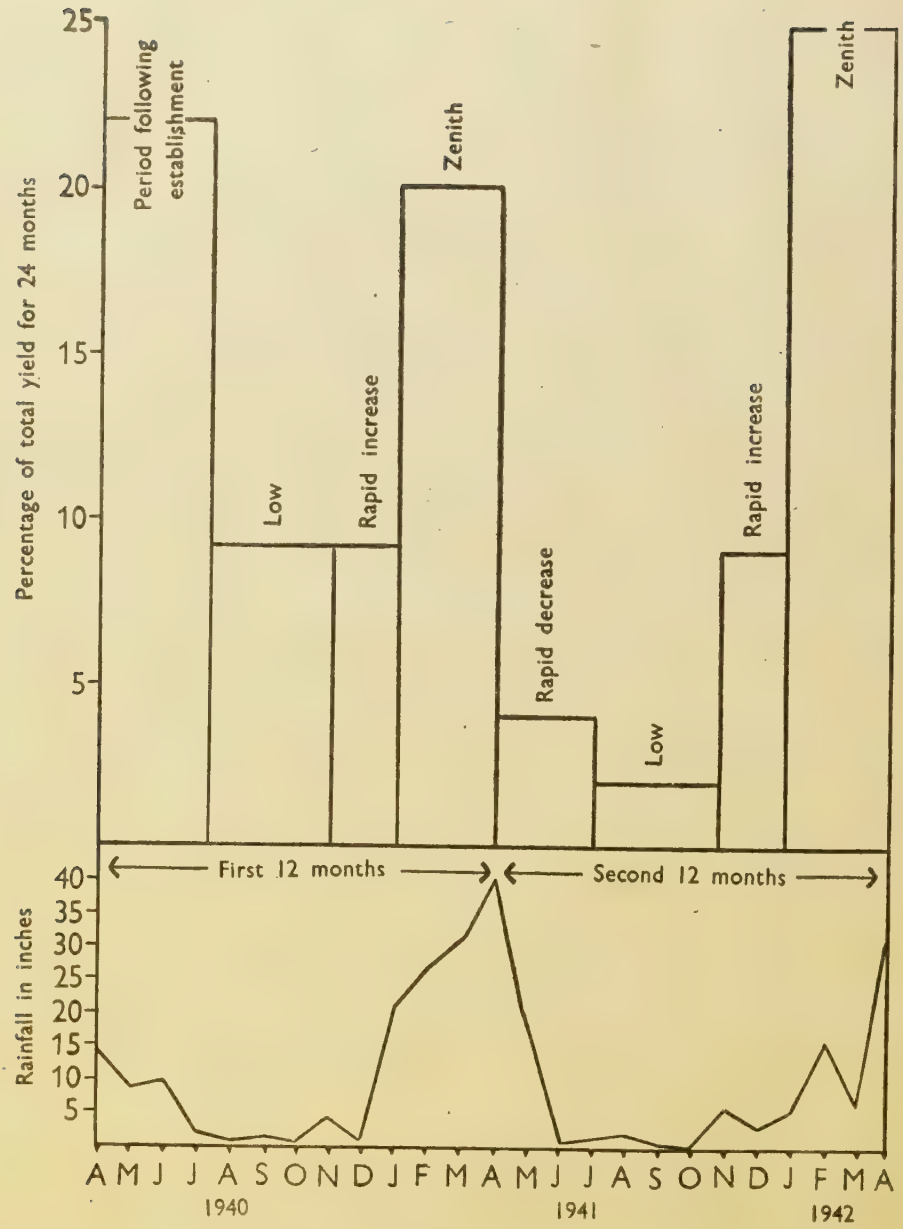

FIG. A.

SHOWING MEAN YIELD IN VARIOUS PRODUCTIVITY PERIODS OF SEVEN GRASSES CUT AT MONTHLY INTERVALS OVER A PERIOD OF TWO YEARS AND RAINFALL DURING THAT PERIOD.

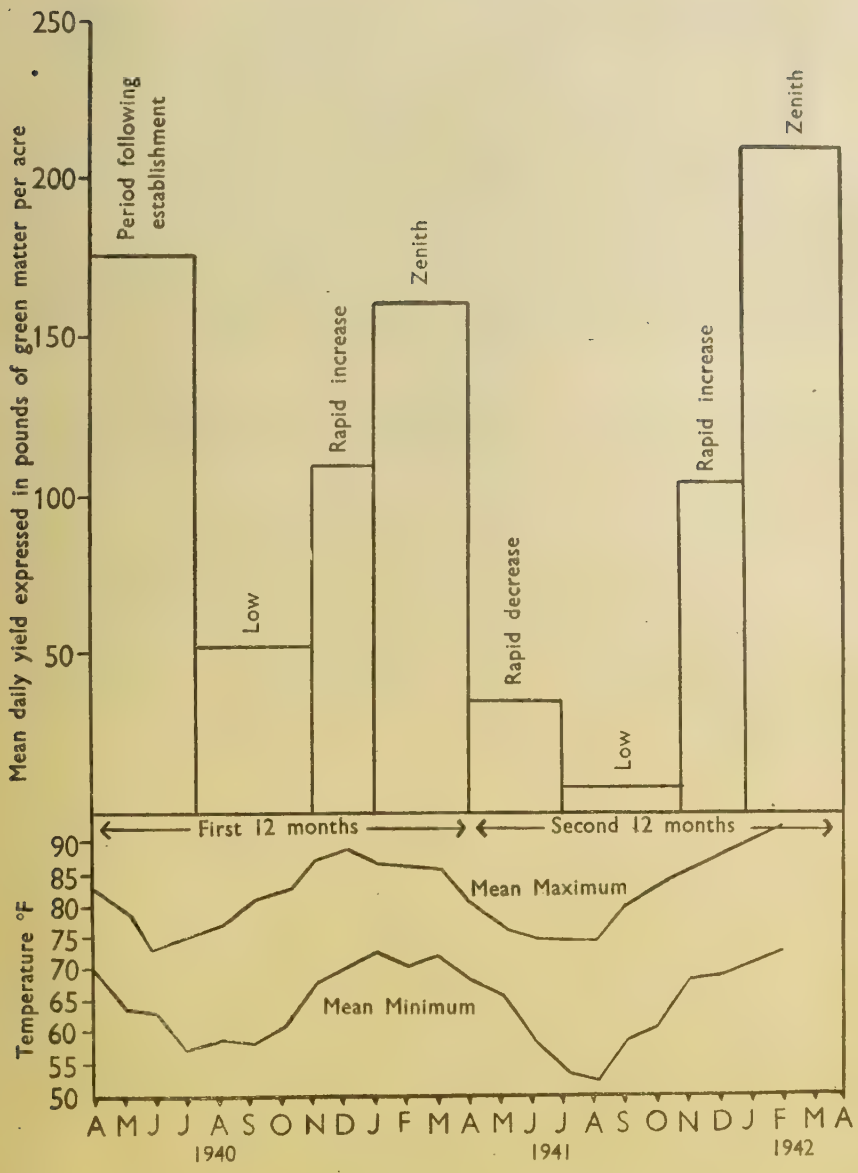

FIG. B.

SHOWING THE MEAN DAILY YIELD IN VARIOUS PRODUCTIVITY PERIODS OF SEVEN GRASSES CUT AT MONTHLY INTERVALS OVER A PERIOD OF TWO YEARS AND AVERAGE TEMPERATURES DURING THAT PERIOD.

DEPARTMENT OF AGRICULTURAL BOTANY
READING UNIVERSITY
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over a considerable portion of the year. The break in the latter correlation occurred during April-May, 1941, when, as previously mentioned, the rainfall incidence was excessive enough to retard grass development. A similar seasonal trend in dry-matter content and its relationship to yield was also observed under both two-monthly and three-monthly cutting rotations. Cutting at these less frequent intervals produced higher dry-matter contents in the grasses.

Special mention must be made of the exceptionally high dry-matter percentage of *Cynodon plectostachyum* under each rotation and in each productivity period. The dry-matter content of this grass is particularly outstanding during the latter portion of the " low productivity " phase when, under monthly cutting the dry-matter percentage is 48.4 ; under two-monthly cutting the figure is 49.2 ; and under the three-monthly rotation a percentage of 53.1 is reached. These figures are from 12 to 15 per cent higher than the average attained by five grasses in the same series.

Field Observations

Throughout the 2 years of investigation notes were taken on the condition of all the grasses prior to each cut. Before taking the first or discard cut the establishment of a full and vigorous stand on every plot was ensured.

Observations of inflorescence emergence indicate a wide range of variation in the incidence, intensity and duration of inflorescence production. Each of the varieties and strains of *Panicum maximum* studied possesses a well-marked periodicity in the times of flower-head formation. Furthermore, the period of maximum inflorescence emergence is associated in these grasses with high yield. This is also true for *Paspalum dilatatum* and in part for *Hyparrhenia aucta* and *Brachiaria decumbens*. It is therefore apparent that a relationship between inflorescence production and yield, similar to that observed in work on temperate grasses, is demonstrated as well by some grasses under the conditions of tropical Queensland.

Variations in Protein Content and Yield as influenced by Seasonal Productivity and Cutting Frequency

This forms the subject of the second investigation which is linked with the productivity experiments just described. At selected cutting periods the protein contents of samples from all the grasses were determined by the standard method.

Data for First 12 Months

Monthly Cuts. Five chemical analyses of each grass were made during the first year of monthly cutting. The first two cuts taken during the period following establishment show an average protein content of 13.1 per cent. The third cut, coinciding with the midwinter period of " low " productivity, is characterized by high protein values of all grasses, the mean being 13.3 per cent. During the periods of " rapid increase " and " zenith " the protein contents show a marked decrease to the mean values of 9.3 and 6.7 per cent respectively. Although certain species exhibit slight differences, the general pattern of protein content indicates a clearly negative correlation between protein content and dry-matter yield.

The total yield of protein given by any grass per acre is dependent not only on the protein percentage, but also on the yield of herbage. Thus, *Brachiaria*

decumbens yields by far the highest amount of protein by virtue of its high productivity which compensates for its relatively low protein percentage, while the protein-rich *Pennisetum clandestinum* and *Digitaria milanjiana* produce only small total amounts of protein owing to their low herbage yields.

Two-monthly Cuts. Protein values obtained for three cuts during the first 12 months demonstrate a generally lower protein content resulting from the longer cutting rotation. Most grasses in the experiment reveal a protein variability pattern similar to that described for monthly cuttings, but there are some important differences among the species. *Chloris gayana* No. 6585 is exceptional in that it shows a rise in protein value under the two-monthly rotation. This is due to the combination of late maturity with leafiness in this particular strain.

Three-monthly Cuts. The fall in protein values already attributed to less frequent cutting was continued under the three-monthly cutting system. As samples were taken from each of the four cuts during the year, it is possible to compare the total yields of protein produced by the different grasses. Figures for the ten most protein-productive species are given in the following table.

Table 6.

	Total yield of protein (lb. per acre)
Brachiaria decumbens	1330
Hyparrhenia aucta	1141
Panicum maximum No. 1202	1103
Melinis minutiflora	995
Urochloa bolbodes	872
Panicum maximum No. 3820	845
Panicum maximum No. 3783	845
Panicum maximum var. *typica*	824
Cynodon plectostachyum	817
Digitaria milanjiana	794

The close correspondence between protein yield and herbage productivity will be noted from a reference to Tables 1, 2 and 3.

Since data are available for the first three monthly cuts and for the first cut under the three-monthly rotation a comparison can be made of corresponding protein yields of each grass under the two systems. Only three grasses record a favourable reaction to three-monthly cutting; *Melinis minutiflora* produced almost twice as much protein under this system, but the increases of *Hyparrhenia aucta* and *Brachiaria decumbens* were negligible. The majority of grasses show considerably higher protein yields under the short rotation, particularly *Panicum maxicum* vars. *coloratum* and *trichoglume*.

Data for Second 12 Months

Only twelve grasses were grown during the second year, but this was sufficient to demonstrate that it is the leafy grasses which show the highest increases in protein content following fertilizer application. The seasonal variation in protein content is again marked, especially in the *typica*, *coloratum* and *trichoglume* varieties of *Panicum maximum*, *Paspalum dilatatum* and *Pennisetum clandestinum*.

General Pattern of Protein Content

All three cutting systems demonstrated that the minimum values for protein content occur with all grasses during the " zenith " period of productivity and that a high level of protein is reached by all grasses in the periods following establishment and during " low " productivity. Further, the herbage productivity periods of " rapid decrease " and " rapid increase " are associated with a rise and fall respectively in protein percentage. This negative correlation between dry-matter yield and protein content can be explained by the leaf to stem ratio which is integrated with the meteorological conditions affecting grass growth. There is an inverse relationship between protein and fibre content under all cutting systems. Those species which are predominantly leafy have the highest protein content throughout each year, while the lowest protein is found in the stemmy grasses.

An Exception to the General Pattern of Protein Yield

Climatic variations in northern Queensland are such that summer rainfall promotes herbage yield, but limits protein production, and dry winter conditions inhibit herbage growth but stimulate protein formation. The reactions of most of the grasses to these seasonal effects follow the general pattern of protein yield, but *Hyparrhenia aucta* is an exception. From July to October its protein yield rises to a maximum and this is obviously associated with the different growth periodicity already described for this grass. If a more palatable grass than *Hyparrhenia aucta* could be found with the same ability to yield abundant protein in the winter-to-spring period of " low " productivity, then one of the most serious problems confronting animal husbandry in Queensland would be solved.

Variations in Mineral Content and Yield as Influenced by Seasonal Productivity and Cutting Frequency

The third paper in this series dealing with investigations on tropical pasture grasses describes the variations in the lime and phosphoric acid contents of the grasses under each cutting rotation. There is plentiful evidence of the strong influence exerted by seasonal productivity on the mineral contents of certain grasses. Rainfall is the chief factor involved, and during the first year of monthly cutting a negative correlation between lime content and rainfall and a positive correlation between phosphoric acid content and rainfall are apparent.

Grasses with a lime content greater than 0.8 per cent under monthly cutting are *Panicum maximum* No. 3820 and vars. *coloratum* and *typica*, and *Urochloa bolbodes*. Five species are medium-rich in lime while the remaining ten are lime-poor. The phosphoric-acid rich grasses, with a mean greater than 0.7 per cent, number thirteen and include the four lime-rich grasses. Apart from *Hyparrhenia aucta* which is very poor both in lime and phosphorus the other grasses have a medium phosphorus content. The same pattern of lime content is shown under two-monthly and three-monthly cutting but the phosphoric acid content of the herbage is reduced by lengthening the cutting rotation.

Yield data show the marked effects of the various periods of productivity on the yield of minerals. During the period following establishment and in the " zenith " period the yields of both lime and phosphoric acid are significantly higher than those

of the other two productivity periods. The ratio of phosphoric acid and lime equivalents is satisfactory for many of the grasses under monthly cutting, but under three-monthly cutting only *Panicum maximum* var. *trichoglume*, *Pennisetum clandestinum*, *Digitaria milanjiana* and *Melinis minutiflora* show a reasonable mineral balance approximating to the standard 1.5 : 1 ratio.

All these investigations go to prove that although there are some grasses satisfactory with respect to yield of dry-matter and to content of protein, phosphoric acid and lime, there are others which need to be grown in association with the suitable legumes that are available for tropical pastures.—M. E. Edwards.

Weeds in Fiji

According to Paper No. 35 of the Legislative Council, Fiji, a Committee was appointed to consider and report on the noxious weed position in Fiji and to make recommendations for the better control of weeds. Paper No. 35 is the Report to the Hon. Colonial Secretary from the Chairman of this Committee, which had the following terms of reference :

(a) to survey all areas, particularly on Viti Levu, spoiled by noxious weeds, and to report on steps necessary to deal with the situation ;

(b) to consider the sending of an officer overseas to investigate methods of weed control ; or

(c) obtaining a trained officer from overseas.

This is probably one of the first serious attempts to deal with the weed problem in a British tropical Dependency.

Part II of the Report is concerned with the distribution of weeds in the Southern, Western and Northern Agricultural Divisions and in other Islands, and is therefore primarily of local interest. The areas surveyed include cultivated land, pasture and fallow land, grazing lands, sugar cane areas, and various proclaimed areas and native lands.

Factors Affecting Spread

The weed flora of Fiji provides many examples of the factors favouring the establishment and spread of dominant plant communities capable of competing with and suppressing natural or induced plant associations. The local weeds of major concern to farmers are aggressive perennials, many with a free seeding habit or effective means of seed dispersal and a tolerance of a wide range of soil and climatic conditions. These factors are supplemented by external factors which may favour the weed rather than the cultivated plant, whether the latter be sugar cane or pasture grass. The major weed species of Fiji and particularly those of grazing land are all well adapted to spread by animals, being provided with bristly fruits or burrs, which cling to the fur or hair of animals. Others have berries which are attractive to birds, pigs, cattle or man. Man is a very important agent of dispersal, spreading weed species along roadsides and footpaths.

In addition to these inherent biological factors, there are often extremely important external factors arising from land tenure and usage, coupled with the

fact that weeds of pastures are not eaten by live stock. These induced conditions often favour the growth of the weed and discourage the growth of the crop. Factors of major importance in the present survey are :—

(1) Short term leases and grazing licences which result in the destruction of grass cover followed by neglect of weeds and failure to maintain the pasture.

(2) The mismanagement of land and stock which generally involves one or more of the following malpractices :—

(a) overstocking and overgrazing,
(b) failure to enclose grazing areas with fences,
(c) failure to subdivide and practice rotational grazing,
(d) neglect of weeding,
and (e) neglect of drainage and soil improvement.

Control Measures

It is necessary to distinguish between control and eradication. If infestation by any weed is limited in extent, vigorous measures may be employed to effect complete eradication without regard to cost. It is not, however, always possible to recognize a plant as a dangerous weed until it has become so widespread that eradication is impracticable because it would cost more than the land is worth. In such a case, and this applies to all weeds which are widespread in Fiji at the present time, action is limited to control, and control aims at the reduction of the intensity of weed infestation to such a level that profitable production of field crops or pastures is possible. The expenditure on control must therefore be related to the potential productivity of the land and the control measures can be applied in most cases only to land which is in productive use. There are additional limits imposed by the form of land tenure, and by the intensity of development of the land as related to the standards of farming reached by the racial groups. Short-term leases and annual grazing licences in particular offer no inducement to the stock owner or farmer to manage his stock and land so as to limit weed growth.

Legislative and Propaganda Measures

During the past 40 years, six weeds have been declared as noxious weeds under ordinances which require occupiers of land to take appropriate measures. The organization of enforcement locally is an important consideration. In Fiji as compared with other countries, there are difficulties arising not so much from the mixed nature of the population as from the varying forms of land utilization which usually have a racial basis. It is difficult in practice to demarcate an area for control purposes to include only land at a similar stage or level of development. It is nevertheless necessary to secure the full co-operation of at least a majority of land occupiers in any area in which control is to be attempted, and it is probably desirable that a measure of responsibility for the enforcement of control measures should be placed on the farmers themselves. Further legislation is also concerned with questions such as short-term grazing leases of Native and Crown lands, and the Trespass Ordinance which requires owners of cattle to confine them within a fence. As regards propaganda the Department of Agriculture should be enabled to indicate to farmers the most efficient methods of control under varying conditions of climate, soil, topography and land utilization.

Cultural Measures

Methods of control may for convenience be grouped as follows :—

(a) mechanical methods : pulling by hand, cutting and mowing, spudding (digging out), tillage, burning ;
(b) smothering, or crowding out with desirable plants by suitable cropping, soil improvement, and controlled grazing ;
(c) biological control ;
(d) chemical methods : herbicides.

As regards smothering or crowding out of weeds, attention is drawn to the fact that it is of little use eradicating one weed if it is only to be replaced by another which has hitherto been held in check. The control of weeds is greatly handicapped unless the farmer manages his land and treats the soil in such a way that the growth of desirable plants is encouraged, so that the temporary setback to weeds afforded by the cultivation of arable land or the clearing of pastures is adequately supported by the vigorous growth of the crop. This has immediate application to many of the pasture lands of Fiji where improvements such as drainage, the planting of desirable grasses, the application of lime and other dressings, fencing to limit the straying stock, and the sub-division of farms to allow for rotational grazing must be regarded as essential aids to the successful and economic control of weeds. Some measure of control of one weed has been achieved by grazing goats through heavily infested areas. None of the other major weeds are palatable to grazing animals, even goats, so that this method appears to be strictly limited.

Recommendations

Having fully considered the present serious position of weed infestation in Fiji and the factors concerned therewith, the Committee recommends the following action.

The existing legislation should be revised to provide for proclamation of weeds in two categories and to define the obligations of land owners and occupiers ; also for the control and restriction of movement of live stock including grazing on roadsides. A full-time Weed Inspector should be appointed to the Department of Agriculture with a period of training in Australia. Landlords should refuse to grant short-term leases and particularly grazing licences and agreements ; all leases should include conditions limiting numbers of live stock and requiring boundary fencing and sub-division. The desirability of legislation on the lines of similar legislation in Australia and New Zealand to provide for the sharing of fencing cost between owners or occupiers of adjoining properties should be further considered. Stricter control should be enforced of the utilization of land in Fijian occupation which is surplus to immediate requirements.

The Department of Agriculture should arrange for the certification of weed-free rice crops for use as seed, and for the provision of seed-cleaning machinery for hire or sale to growers and rice merchants. The Department of Agriculture should be enabled to undertake investigations into methods of direct control of weeds and into methods of pasture and grazing improvement. A limited number of flame throwers and fuel should be provided to permit an early start to be made on the control of certain weeds.

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List of Weeds Recorded

Proclaimed
Solanum torvum
Urena lobata var. *scabriuscula*

Recommended for Proclamation
Hyptis pectinata
Ischaemum rugosum
Mimosa invisa
Sorghum halepense
Xanthium italicum

Formerly Proclaimed but no longer so
Acacia farnesiana
Clidemia hirta
Eichhornia crassipes
Xanthium italicum

Aggressive
Brachiaria mutica
Chrysopogon aciculatus
Cuphea carthagenensis
Cyperus rotundus
Dicanthium caricosum
Digitaria pruriens
Echinochloa crus-pavonia
Imperata exaltata
Jussiaea erecta
Lantana aculaeata
Mikania micrantha
Paspalum conjugatum
Piper aduncum
Psidium guajava
Sida thombifolia
Solanum torvum
Sorghum halepense
Stachytarpheta urticaefolia
Triumfetta bartramia
Urena lobata var. *scabriuscula*
Zizyphus jujuba

Pastures and Fodder Plants in Sierra Leone

Trials on the provision of animal fodder have only recently started in Sierra Leone, and Agriculture Note No. 6 of June, 1944, published in mimeographed form by the Director of Agriculture provides a review of present knowledge and practices, and of the potentialities of indigenous and exotic species. It is regarded as obvious that work should begin with fodder plants already in the country, of which there are several adapted to different habitats; exotic plants can only be considered if trials indicate that they are at least as good as the indigenous types.

The native method of management on grassland gives little promise for development. Fodder is abundant during the rainy season but scarce in the dry season and green dry-season fodder is produced by burning patches of grassland to promote the growth of green shoots. The grassland vegetation does not provide a good soil cover during the dry season, when it is being trampled by cattle and the soil is therefore very liable to erosion by the early tornado rains.

Although palatable grasses such as *Andropogon tectorum* are common in many areas, these are of the tussock type and do not bind the soil well, nor do they remain green throughout the dry season. The greatest difficulty, however, lies in the progressive deterioration of the natural grasslands because of the selective grazing of these more palatable grasses, which benefits *Chasmopodium*, the commonest tall tufted grass in Sierra Leone, which is unpalatable except for its young shoots. This seeds abundantly and early, and becomes dominant.

Only in certain areas where there are pure stands of Elephant grass is there any

hope of improved management of natural fodder grasslands. In the Belgian Congo, 7.5 to 37.5 acres of natural grassland are recommended to be necessary per cow, and the figure for Sierra Leone must be similar.

Artificial Pastures and Cut Fodder

It would appear to be possible to establish artificial pastures and cut fodder plots quickly in Sierra Leone using Guinea grass (*Panicum maximum*), the palatable and nutritious legume, *Pueraria*, and a good perennial fodder and possibly even pasture grass in Elephant grass. All these will cover the ground effectively and prevent erosion, and, except for *Pueraria* which loses most of its leaves in February to March, will remain green throughout the dry season on the uplands. In addition there are local grasses and legumes which appear to be suitable for permanent pasture and fodder in swamps and low-lying places for dry-season feed. Other (annual) species may be suitable for dry-season cultivation in swamps or for cultivation in the wet or the early dry-season upland plots, possibly in rotation with arable crops.

The difficulty seems to be in finding a low-growing fodder plant capable of making a sward suitable for an upland dwarf pasture and able to keep green throughout the dry season. Some forms of *Paspalum scrobiculatum* appear to keep green longest but all the other local short perennial grasses or legumes dry up during January, February or March. One object must be to use a mixture which will bind the soil and sufficiently withstand trampling to prevent erosion. *Panicum laxum* appears to be promising in this respect.

Supplementary and Dry Season Fodder

No pasture can be expected to support the same number of cattle per acre in the dry season and in the rains, and a supplementary fodder is thus essential from January to May unless the herds are reduced at this period. The native cattle owner does not appreciate the value of cut fodder and hay is practically unknown to him, although it is apparently sold in the markets of French Guinea, French Sudan and Northern Nigeria. It is therefore necessary to educate him to use cut fodder, to make and conserve hay and to grow plots of plants such as *Pueraria*, Guinea grass and Elephant grass fenced both for cutting and for grazing. Propaganda and demonstration concerning the value of farmyard manure must also be carried out.

Even if the native is ultimately made to realize the value of supplementary cut fodder and hay he will naturally still wish to graze his cattle as much as possible. In order to induce him to practise rotational grazing of artificial pastures he must first be persuaded of the value of the planted fodder plots protected by fencing for cut fodder or hay. It is unlikely that ensilage will be practicable for many years to come, nor is it likely that a native can be induced to grow human food plants such as maize, groundnuts and cowpeas merely as fodder for cattle while these crops command such a high price in local markets. The stubble, dry tops, or other crop residues may, however, be of great value. At least one cereal, the tall, large-grained Guinea corn, *Sorghum gambicum* var. *celsum* is grown specifically for live stock in some parts, chiefly for horses.

Pastures and Soil Erosion

The heavy rainfall of Sierra Leone makes soil erosion an ever-present problem

and one to be guarded against before any other question is considered. If it were possible to keep live stock only by constantly exposing the soil to the risk of erosion, one would be forced to conclude that live stock in Sierra Leone ought to be reduced to a minimum. The high palatability or nutritive value of a fodder plant does not therefore alone make it a desirable species to grow ; it must first, either as a pure crop or in a mixture with other plants, be capable of preventing soil erosion.

The following may therefore be said to be the essential requirements of a temporary or permanent pasture or fodder plot.

(a) The constituent plants must under good management be of such a habit as to form a closed vegetative cover which will not allow soil erosion to occur. In a permanent pasture or fodder crop they must therefore be perennial.

(b) No constituent of the vegetation must be poisonous or distasteful to live stock although distasteful plants may be suitable for planting in areas where trampling or grazing by cattle is undesirable from the point of view of soil erosion.

(c) At least the most abundant constituents of the vegetation must be palatable and nutritious to live stock. While it is not essential that all constituents should be so, the value of a plot obviously increases according as fewer unpalatable plants appear in the vegetation.

For a permanent pasture the following additional requirements must be fulfilled.

(d) The constituent plants must be able to withstand grazing and trampling.

(e) The vegetation should as far as possible remain green throughout the dry season.

With the exception of Elephant grass, the natural grassland vegetation of Sierra Leone does not fulfil all these requirements. There appears to be no way of using the smaller annual grasses except as wayside fodder. *Eleusine indica* is a possible exception because of its relative longevity and deep roots. Even with permanent plots kept as fodder, it is of advantage that they should be grazed occasionally if only lightly, both to manure them and to induce a good growth habit. Probably both Elephant grass and Guinea grass would be improved by grazing fairly close when the rains begin.

Useful Grasses and Legumes

Permanent Pastures.

Upland Areas.

Panicum maximum (Guinea grass)
Pueraria phaseoloides (Rhodesia Kudzu)

Moist Low-Lying Areas and/or Swamps, for dry season pasture.

Acroceras amplectans
Acroceras zizanioides
Paspalum vaginatum (especially tidal swamps)

Short-grass Upland Paddocks. (It is doubtful if any will remain green during the dry season.)

Axonopus compressus
Cynodon dactylon
Panicum laxum
Paspalum conjugatum (in more moist areas).
Paspalum scrobiculatum (some varieties)
Stenotaphrum secundatum
Desmodium triflorum (in a mixture with grasses)

Sandy Soils, especially Coastal Areas.

Panicum repens
Stenotaphrum secundatum
Cassia mimosoides
Stylosanthes erecta

PERMANENT FODDER PLOTS.

Upland Areas.

Panicum maximum (Guinea grass)
Pennisetum purpureum (Elephant grass)
Pueraria phaseoloides (Rhodesia Kudzu)
Setaria chevalieri, perhaps.

Swamps.

Echinochloa pyramidalis
Saccolepis africana
Desmodium salicifolium, possibly
Vossia cuspidata

ANNUAL FODDER PLANTS.

Coix lachryma-jobi (swamps in dry season)
Echinochloa colona (swamps in dry season)
Eleusine indica (possible wet-season paddock grass)
Rottboellia exaltata
Sorghum arundinaceum
Desmodium gangeticum
Dolichos lablab, in dry season
Mucuna aterrima (Bengal bean), in dry season
Phaseolus calcaratus (Jerusalem pea), and other *Phaseolus* spp.
Sesbania spp.

The Notes contain reference to the characteristics of these and many other species, with detailed notes on the establishment and management of Guinea grass (*Panicum maximum*) pastures, on the adaptability and non-palatable nature of *Melinis minutiflora*, and on the merits of Elephant grass (*Pennisetum purpureum*) and of sugar cane and Uba cane (*Saccharum officinarum*).

The exotic grasses considered to deserve a trial are :

Brachiaria mutica
Eriochloa subglabra
Chloris gayana
Coleorachis glandulosa
Cynodon plectostachyum
Euchlaena mexicana
E. perennis
Panicum trichocladum
Paspalum dilatatum
Pennisetum clandestinum
Tripsacum laxum
Sorghum halepense
S. sudanense
S. virgatum

The list of herbaceous leguminous fodder plants is as follows :—

Alysicarpus vaginalis
Arachis hypogaea
Calopogonium mucunoides
Canavalia ensiformis
Cassia mimosoides
C. kirkii
Centrosema plumieri
Crotalaria
Medicago sativa
Mimosa pudica
Mucuna aterrima
M. nivea
Phaseolus
Pueraria phaseoloides
P. hirsuta
Sesbania aculeata

DEPARTMENT OF AGRICULTURAL BOTANY
READING UNIVERSITY
ENGLAND.

Desmodium
Dolichos biflorus
D. hosei
D. lablab
Indigofera
Stylosanthes erecta
Tephrosia
Vigna
Zornia diphylla

The following trees and non-leguminous herbs are eaten by live stock :

Acacia pennata
Adansonia digitata
Afzelia africana
Aralia guilfoylei
Asystasia gangetica
Bauhinia thonningii
Commelina nudiflora
Eryngium foetidum
Helianthus annuus
Lannea afzelii
Leucaena glauca
Mikania scandens
Mimosa rubricaulis
Moringa pterygosperma
Panax fruticosum
Parkia biglobosa
Peucedanum fraxinifolium
Prosopis chilensis
Pterocarpus erinaceus
Samanea saman
Spigelia anthelmia
Zizyphus jujuba

The article closes with a list of plants suspected of being toxic to live stock.—R. O. WHYTE.

Land Resources of Tripolitania

The British Military Administration published in August 1945 the report of a Survey of Land Resources in Tripolitania, which had been carried out chiefly by Captain J. W. Rowland, Research Officer of the Department, formerly and now again of the Department of Agriculture, South Africa. The main purposes were :

(a) to determine the present land resources ;
(b) to ascertain the different systems of land use, their distribution and extent ;
(c) to assess potentialities for future development ;
(d) to obtain data necessary for the formulation of long-term agricultural policy.

The productive land amounts to some ten million hectares of which eight million hectares are suitable only for grazing use. Of the remaining two million hectares, about 400,000 are devoted to static farming, but this area is not fully developed. Shifting cereal cultivation by Arabs is found in irregular patches throughout the remaining 1,600,000 hectares.

In its present state, agriculture cannot provide enough to maintain economic stability. The problem then is :

Can agriculture which henceforth may be regarded as the main source of wealth be developed to the extent of absorbing all those requiring employment in the post-war period, and is the productive capacity of the country sufficient to enable it to pay its way ?

The planning of agriculture and the development of land resources can be based on meeting local requirements and any demand for export goods capable of competing on the world market. The country is self-supporting but for sugar, coffee, tea and cotton goods, and export commodities are limited to live-stock products, olive oil, and

possibly early vegetables, dates and wine. It is considered that, although seven-tenths of the area is semi-desert, the country as a whole lends itself to live-stock production. The grazing areas comprise a comparatively narrow strip of some 500 miles along the seaboard, 130 miles deep on the west and 30 deep on the east. " The Arab is a shepherd at heart and live stock production is a traditional part of his way of life."

The static farming areas along the coast and on the cool Gebel are suited to summer feeding of live stock. As the extensive grazing areas are all within walking distance of the static farming areas, it is considered possible to apply a system of grazing management mutually beneficial to both. During winter when the weather is cool and water requirements low, the live stock should be dispersed on the extensive semi-arid regions, " leaving as few as possible on the static farming areas." It would then be possible to build up reserves of forage crops for summer feeding when the grazing animals return to the static areas. In addition to the provision of drinking water in the semi-desert areas,it is recommended that forage trees, bushes and crops should be planted in the static areas to meet feeding requirements during the summer.

It is stressed that the different forms of land use require to be integrated and properly co-ordinated. The Italian development of intensive farming as a separate and independent entity has, according to this survey, led to dislocation, waste and considerable conflict of interests. " The Italian colonist is equipped for certain forms of farming which cannot be undertaken by the static or semi-nomadic Arab." This applies particularly to the breeding of stud animals, the proper feeding of stock for the export market, and the production of milk for urban requirements, all enterprises depending for their economic success on the feeding of high-grade fodders expensive to produce to high-grade live stock capable of giving an adequate economic return.

It is, however, a debatable point whether the growing of fodder crops for the summer feeding of the low-grade animal of the nomadic Arab can ever be regarded as economic, whether fodder trees and shrubs can ever be planted (or managed on a sustained yield basis) on a scale sufficient to meet the demands of the three million sheep equivalents which it is claimed can be maintained in place of the one million as at present. The combination of the sheep and the goat makes a very efficient grazing weapon, and one is bound to ask whether the semi-desert areas are semi-desert because of the climate or because of the drastic treatment they have received in centuries of " the Arab way of life." That it is unfair to blame the Arab entirely can be seen from the many examples where static Arabs appreciate the value of growing fodder crops for stall-feeding to high-grade animals.

The improvement of live stock by controlled mating and culling of undesirable males is among the recommendations of this survey (which should be studied by all concerned with grazing and the potentialities of reviving ruined vegetative cover on the desert fringes) but it is not appreciated that any great advance in quality of animal by selection will make these animals so demanding in their nutritional requirements that they can no longer live on the semi-desert scrub, and will therefore be no longer of use to the nomadic Arab.

A table giving the types of vegetation in the grazing areas of Tripolitania is reproduced on p. 128 of I.A.B. Joint Publication No. 10, " The use and misuse of shrubs and trees as fodder."—R. O. Whyte.

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